STANDARD SPECIFICATIONS FOR CONSTRUCTION OF ROADS AND BRIDGES ON FEDERAL HIGHWAY PROJECTS

FP-14

U.S. Department
of Transportation

**Federal Highway
Administration**

Federal Lands Highway

Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects

FP-14

UNITED STATES DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

PREFACE

These Standard Specifications for the Construction of Roads and Bridges on Federal Highway Projects are issued primarily for constructing roads and bridges on Federal Highway projects under the direct administration of the Federal Highway Administration. These specifications are cited as "*FP-14*" indicating "*Federal Project*" Standard Specifications issued in 2014 and contain both United States Customary and Metric units of measure.

When designated in a contract, the FP-14 becomes part of the contract and binding upon all parties to the contract. Construction contracts of the Federal Highway Administration are also governed by the following regulations:

- Federal Acquisition Regulation (FAR), Title 48, Code of Federal Regulations, Chapter 1; and
- Transportation Acquisition Regulation (TAR), Title 48, Code of Federal Regulations, Chapter 12.

The FAR and TAR regulations are not included in the FP-14. A complete copy of the FAR is available from the Superintendent of Documents, Congressional Sales Office, U.S. Government Printing Office, Washington, DC 20402.

U.S. Customary units of measure are used in the FP-14 as provided in the November 25, 2008 Memorandum from Jeffrey F. Paniati entitled *Update on Metric Use Requirements for FHWA Documents*. Metric units are noted in parentheses following the U.S. Customary Units. The references to Metric or Metric units apply only when the project or portion of the project expressly calls for Metric units of measure.

METRIC TO U.S. CUSTOMARY CONVERSION FACTORS (approximate)				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
µm	micrometers	3.9×10^{-5}	inches	in
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.31	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.2046	pounds	lb
Mg	megagrams	1.1023	short tons	T
(or "t")	(or "metric ton")		(2000 lb)	
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8C +32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		MISCELLANEOUS		
J	joule	0.7376	foot·poundforce	ft·lbf
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	Poundforce per square inch	lbf/in^2

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DIVISION 100
GENERAL REQUIREMENTS

Section 101. — TERMS, FORMAT, AND DEFINITIONS

101.01 Meaning of Terms. These specifications are generally written in the imperative mood. In sentences using the imperative mood, the subject, "*the Contractor*", is implied. Also implied in this language are "*shall*", "*shall be*", or similar words and phrases. In material specifications, the subject may also be the supplier, fabricator, or manufacturer supplying material, products, or equipment for use on the project.

Wherever "*directed*", "*required*", "*prescribed*", *or* "*ordered*" are used, the "*direction*", "*requirement*", "*prescription*", or "*order*" of the Contracting Officer is intended. Wherever something is to be "*submitted*", "*submitting to*", the Contracting Officer is intended. Similarly, wherever "*approved*", "*acceptable*", "*suitable*", "*satisfactory*", or similar words are used, the words mean "*approved by*", "*acceptable to*", or "*satisfactory to*" the Contracting Officer.

The word "*will*" generally pertains to decisions or actions of the Contracting Officer.

101.02 Specifications Format. These specifications are divided into 10 Divisions.

Division 100 consists of general contract requirements for which no direct payment is made. The requirements contained in Division 100 are applicable to all contracts.

Division 150 consists of project contract requirements that are applicable to all contracts. Work under Division 150 is paid for directly or indirectly according to Subsection 109.05 and the Section ordering the work. When there is no pay item in the bid schedule, no direct payment is made.

Divisions 200 through 600 consist of construction contract requirements for specific items of work. Work under these Divisions is paid for directly or indirectly according to Subsection 109.05 and the Section ordering the work. When there is no pay item in the bid schedule, no direct payment is made.

Division 700 contains the material requirements for Divisions 150 through 600. No direct payment is made in Division 700. Payment for material is included as part of the work required in Divisions 150 through 600.

The first three digits of the pay item number in the bid schedule identify the Section under which the work is performed.

101.03 Abbreviations. Whenever these abbreviations are used in the contract, they represent the following:

(a) Acronyms.

AASHTO — American Association of State Highway and Transportation Officials

ACI — American Concrete Institute

AGC — Associated General Contractors of America

AISC — American Institute of Steel Construction

AITC — American Institute of Timber Construction

ANSI — American National Standards Institute

APWA — American Public Works Association

ARTBA — American Road and Transportation Builders Association

ASME — American Society of Mechanical Engineers

ASTM — ASTM International

ATSSA — American Traffic Safety Services Association

AWPA — American Wood Protection Association

AWS — American Welding Society

AWWA — American Water Works Association

BMP — Best Management Practice

CFR — Code of Federal Regulations

CO — Contracting Officer and authorized representatives

CRSI — Concrete Reinforcing Steel Institute

EPA — Environmental Protection Agency

FAR — Federal Acquisition Regulations (48 CFR Chapter 1)

FHWA — Federal Highway Administration

FICA — Federal Insurance Contributions Act

FLH — Federal Lands Highway

FSS — Federal Specifications and Standards

FED-STD — Federal Standards

FUTA — Federal Unemployment Tax Act

ISO — International Organization for Standardization

ISSA — International Slurry Surfacing Association

JMF — Job-Mix Formula

MASH — Manual for Assessing Safety Hardware

MPI — Master Painters Institute

MSDS — Material Safety Data Sheet

MUTCD — Manual on Uniform Traffic Control Devices for Streets and Highways

NCHRP — National Cooperative Highway Research Program

NEMA — National Electrical Manufacturers Association

NIST — National Institute of Standards and Technology

OSHA — Occupational Safety and Health Administration

PCI — Precast/Prestressed Concrete Institute

PVC — Polyvinyl Chloride

PTI — Post-Tensioning Institute

SEP — Sand Equivalent Passing

SF — Standard Form

SI — International System of Units

SSPC — The Society for Protective Coatings

SWPPP — Storm Water Pollution Prevention Plan

TAR — Transportation Acquisition Regulations (48 CFR Chapter 12)

UL — Underwriter's Laboratory

U.S. — United States of America

USC — United States Code

(b) U.S. Customary unit abbreviations and symbols.

°F	—	degree Fahrenheit	temperature
ft	—	feet	length
ft^2	—	square feet	area
ft^3	—	cubic feet	volume
in	—	inches	length
in^2	—	square inches	area
in^3	—	cubic inches	volume
lb	—	pound	mass
mi	—	mile	length
oz	—	ounces	mass
psi	—	pounds per square inch	pressure
T	—	ton (2000 lb)	mass
yd	—	yards	length
yd^2	—	square yards	area
yd^3	—	cubic yards	volume
s	—	second	time
°	—	degree	plane angle
'	—	minute	plane angle
"	—	second	plane angle

(c) Metric unit abbreviations and symbols.

A	—	ampere	electric current
cd	—	candela	luminous intensity
°C	—	degree Celsius	temperature

d	—	day	time
g	—	gram	mass
H	—	Henry	inductance
ha	—	hectare	area
Hz	—	hertz (s^{-1})	frequency
J	—	joule (N•m)	energy
K	—	kelvin	temperature
kg	—	kilogram	mass
L	—	liter	volume
lx	—	lux	illuminance
m	—	meter	length
mm	—	millimeter	length
m^2	—	square meter	area
m^3	—	cubic meter	volume
min	—	minute	time
N	—	newton ($kg•m/s^2$)	force
Pa	—	pascal (N/m^2)	pressure
t	—	metric ton	mass
V	—	volt (W/A)	electric potential
W	—	watt (J/s)	power
Ω	—	ohm V/A	electric resistance

(d) Metric prefix symbols.

E	—	exa	10^{18}
P	—	peta	10^{15}
T	—	tera	10^{12}
G	—	giga	10^{9}
M	—	mega	10^{6}
k	—	kilo	10^{3}
c	—	centi	10^{-2}
m	—	milli	10^{-3}
μ	—	micro	10^{-6}
n	—	nano	10^{-9}
p	—	pico	10^{-12}
f	—	femto	10^{-15}

a — atto 10^{-18}

(e) Slope notation (vertical : horizontal). For slopes flatter than 1V:1H, express the slope as the ratio of one unit vertical to a number of units horizontal. For slopes steeper than 1V:1H, express the slope as the ratio of a number of units vertical to one unit horizontal.

101.04 Definitions. The following definitions apply to this contract:

Award — The written acceptance of a bid by the CO.

Backfill — Material used to replace or the act of replacing material removed during construction. Material placed or the act of placing material adjacent to structures.

Base — The layer or layers of material placed on a subbase or subgrade to support a surface course.

Bid — A written offer by a bidder to perform work at a quoted price.

Bidder — An individual or legal entity submitting a bid.

Bid Guarantee — A form of security assuring that the bidder will not withdraw a bid within the period specified for acceptance and will execute a written contract and furnish required bonds.

Bid Schedule — The prepared schedule included with the bid forms, containing the estimated quantities of pay items for which unit bid prices are invited.

Bridge — A structure more than 20 feet (6 meters) long, including supports, spanning and providing passage over a depression, waterway, railroad, highway, or other obstruction.

Clear Zone — The portion of the roadside, including the shoulder, available for the safe use by an errant vehicle in which the driver may regain control of the vehicle.

Commercial Certification — See Subsection 106.03.

Construction Limits — The limits on each side of the project that establish the area disturbed by construction operations and beyond which no disturbance is permitted. Typically the construction limits are the same as the clearing limits, except when additional clearing is required.

Contract — The written agreement between the Government and the Contractor setting forth the obligations of the parties for the performance of and payment for the prescribed work.

Contracting Officer (CO) — An official of the Government with the authority to enter into, administer, and terminate contracts and make related determinations and findings. The term includes certain authorized representatives of the CO acting within the limits of their authority as delegated by the CO.

Contract Modification — A written change in the terms of the contract. Contract modifications are of the following forms:

(a) Administrative change. A unilateral contract change, in writing, that does not affect the substantive rights of the parties (such as a change in the paying office or the appropriation data).

(b) Change order. A written order, signed by the CO, directing the Contractor to make a change that FAR Clause 52.243-4 Changes authorizes the CO to order without the Contractor's consent.

(c) Supplemental agreement. A contract modification that is accomplished by the signature of the CO (unilateral contract modification) or by the signature of the CO and the Contractor (bilateral contract modification).

Contractor — The individual or legal entity contracting with the Government for performance of prescribed work.

Contract Time — The specified time allowed for completion of contract work.

Crashworthy — A highway feature that has been successfully crash tested under MASH or the NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, or accepted through analysis by FHWA based on similarity to other crashworthy features.

Cross-Section — A vertical section of the ground or structure at right angles to the centerline or baseline of the roadway or other work.

Culvert — A structure, not classified as a bridge, that provides an opening under the roadway.

Day — A calendar day beginning and ending at midnight.

Density — Mass per unit volume of material. Specific gravity multiplied by the density of water.

Detour — A temporary rerouting of public traffic onto alternate existing roadways to avoid the work or part of the work.

Diversion — Defined as follows:

(a) A temporary rerouting of public traffic onto a temporary alignment within the project limits to bypass the work or a portion of the work.

(b) A temporary rerouting of water into a temporary channel or through a system of structures within the project limits to maintain water flow through or around the project.

Drawings — Design sheets or fabrication, erection, or construction details submitted to the CO by the Contractor according to FAR Clause 52.236-21 Specifications and Drawings for Construction. Also refers to submissions and submittals.

Federal Land Management Agencies — Federal agencies including the National Park Service, U.S. Forest Service, U.S. Fish & Wildlife Service, U.S. Army Corps of Engineers, Bureau of Land Management, and Bureau of Reclamation.

Government — The Government of the United States of America.

Highway, Street, or Road — A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Lane Mile (Lane Kilometer) — An area of pavement one mile (kilometer) long and one lane wide; not including turn lanes, turnouts, parking area lanes, or other auxiliary lanes.

Layer — See "lift".

Lift — Defined as follows:

(a) When placing and compacting soils, aggregates, or pavement; a lift is a single, continuous layer of material that receives the same compactive effort throughout during a single work operation.

(b) When installing culvert pipe less than or equal to 48 inches (1200 millimeter) in diameter; the backfill material placed on both sides of the pipe is considered to be contained in the same lift when the material is placed to the same elevation on both sides of the culvert, the compactive effort applied to one side of the culvert is the same as that applied to the other, and the compactive effort is applied to both sides of the pipe in a continuous operation.

Material — Substances specified or necessary to satisfactorily complete the contract work.

Measurement — The process of identifying the dimensions, quantity, or capacity of a pay item. See Section 109 for measurement methods, terms, and definitions.

Notice to Proceed — Written notice to the Contractor to begin the contract work.

Pavement Structure — The combination of subbase, base, paving geotextiles, and surface courses placed on a subgrade to support and distribute the traffic load to the roadbed.

Pay Item — A specific item of work for which a unit and price is provided in the contract.

Payment Bond — The security executed by the Contractor and surety or sureties and furnished to the CO to ensure payments as required by law to persons supplying labor or material according to the contract.

Performance Bond — The security executed by the Contractor and surety or sureties furnished to the CO to guarantee completion of the contract work.

Plans — The contract plans furnished by the Government showing the location, type, dimensions, and details of the work.

Production Certification — See Subsection 106.03.

Professional Engineer — Engineers holding valid state licenses permitting them to offer engineering services directly to the public. Engineers that are experienced in the work for which they are responsible, take legal responsibility for their engineering designs, and are bound by a code of ethics to protect the public health.

Profile Grade — The trace of a vertical plane intersecting a particular surface of the proposed road construction located according to the plans, usually along the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of the trace according to the context.

Project — The specific section of the highway or other property on which construction is to be performed under the contract.

Right-of-Way — Real property necessary for the project, including roadway, buffer areas, access, and drainage areas.

Roadbed — The graded portion of a highway prepared as a foundation for the pavement structure and shoulders.

Roadside — The area between the outside shoulder edge and the right-of-way limits. The area between roadways of a divided highway may also be considered roadside.

Roadway — In general, the portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways. In construction specifications, the portion of a highway within the construction limits.

Roadway Prism — The volume defined by the area between the original terrain cross-section and the final design cross-section multiplied by the horizontal distance along the centerline of the roadway.

Roller Pass— One trip of a roller in one direction over one spot.

Shoulder — A portion of the roadway contiguous with the traveled way that accommodates pedestrians, bicycles, stopped vehicles, and emergency use; as well as for lateral support of the subbase, base, and surface courses.

Sieve — See AASHTO M 92.

Solicitation — The complete assembly of documents (whether attached or incorporated by reference) furnished to prospective bidders.

Special Contract Requirements (SCR) — Additions and revisions to the standard specifications applicable to an individual project.

Specifications — The written requirements for performing work.

Standard Forms (SF) — Numbered forms issued by the General Services Administration for use as contract documents.

Standard Specifications — The Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects approved for general application and repetitive use.

Station — A precise location along a survey line.

Structures — Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, foundation drains, and other constructed features that may be encountered in the work.

Subbase — The layer or layers of material placed on a subgrade to support a base.

Subcontract — The written agreement between the Contractor and an individual or legal entity prescribing the performance of a specific portion of the work.

Subcontractor — An individual or legal entity with which the Contractor sublets part of the work. This includes subcontractors in all tiers.

Subgrade — The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.

Substantial Completion — The point at which the project is complete such that it can be safely and effectively used by the public without further delays, disruption, or other impediments. For conventional bridge and highway work, the point at which bridge deck, parapet, pavement structure, shoulder, drainage, sidewalk, major demolition, roadway obliteration, permanent signing and markings, traffic barrier, safety appurtenance, utility, and lighting work is complete.

Substructure — Components of a bridge below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames including backwalls, wingwalls, and wing protection railings.

Suitable Material — Rock or earth material that will provide stable foundations, embankments, or roadbeds, and is free of organic matter, muck, frozen lumps, roots, sod, or other deleterious material. Suitable material may require drying or adding water, root picking, and other methods of manipulation before use. Suitable material includes the classifications of material for which the project was designed.

Superintendent — The Contractor's onsite representative who has authority to act for the Contractor and is responsible for directing and supervising construction operations on behalf of the Contractor.

Superstructure — The entire bridge, except the substructure.

Surety — An individual or corporation legally liable for the debt, default, or failure of a Contractor to satisfy a contract obligation.

Surface Course — The top layer or layers of a pavement structure designed to accommodate the traffic load and resist skidding, traffic abrasion, and weathering.

Target Value — A number established as a center for operating a given process. Once established, adjustments should be made in the process as necessary to maintain a central tendency about the target value. Test results obtained from a well-controlled process should cluster closely around the established target value and the mean of the test results should be equal to or nearly equal to the established target value.

Traveled Way — The portion of the roadway designated for the movement of vehicles, exclusive of shoulders.

Unsuitable Material — Material not capable of creating stable foundations, embankments, or roadbeds. Unsuitable material includes muck, sod, or soils with high organic contents.

Work — The furnishing of labor, material, equipment, and other incidentals necessary to complete the project according to the contract.

Section 102. — BID, AWARD, AND EXECUTION OF CONTRACT

102.01 Acquisition Regulations. Bid, award, and execution of the contract is governed by the FAR and TAR.

102.02 Preparation of Bids. Follow the requirements of FAR Clause 52.214-18 Preparation of Bids - Construction.

Execute and submit required standard forms, bid schedules, and solicitation provisions contained in the solicitation as part of the bid.

Complete SF 1442, *Solicitation, Offer, and Award*, and sign as follows:

(a) Individuals. Sign your individual signature. For individuals doing business as a firm, follow the individual signature with the individual's typed, stamped, or printed name and the words, "*an individual doing business as* *(name of firm)*".

(b) Limited liability partnerships and partnerships. Submit a list of partners having authority to bind the partnership. One of the listed partners must sign on behalf of the partnership.

(c) Corporations. Sign in the corporate name, followed by the word "*by*" and the signature and title of the person authorized to sign. Submit evidence from the corporation that the person signing has authority to bind the corporation.

(d) Joint ventures. Submit a copy of the Joint Venture agreement. Sign the SF 1442 according to the Joint Venture agreement.

(e) Limited liability company. Sign in the company name, followed by the word "*by*" and the signature of the person authorized to sign. Submit evidence that the individual executing the document has authority to bind the company.

(f) Agents. When an agent signs, other than as stated in Subsection 102.02(a) through (e), furnish satisfactory evidence that the agent has authority to bind the bidder.

Insert a numeric unit bid price for each pay item for which a quantity appears in the bid schedule. Multiply the unit bid price by the quantity for each pay item and show the amount bid. When mathematical checks made by the Government show a mistake in the amount bid, the corrected unit price extension governs.

When the words "*lump sum*" appear as a unit bid price, insert an amount bid for each lump sum pay item.

When the words "*contingent sum*" or "*fixed rate*" appears as a unit bid price, include the Government inserted amount bid for the pay item in the total bid amount.

Total the amounts bid for each pay item and show the total bid amount.

The quantities listed in the bid schedule are approximate, unless designated as a contract quantity, and are used for the comparison of bids. Payment will be made for the actual quantities of work performed and accepted or material furnished according to the contract. The scheduled quantities may be increased, decreased, or deleted. Bid schedule quantities are considered the original contract quantities.

102.03 Bid Guarantee. Follow the requirements of FAR Clause 52.228-1 Bid Guarantee.

(a) General. Submit the bid guarantee on SF 24, *Bid Bond*. If the bid guarantee is other than a corporate or individual surety, sign the SF 24 as the principal and make a statement on the form pledging the security. Make checks or money orders payable to the agency issuing the solicitation.

(b) Power of attorney. A corporate surety shall submit a current power of attorney for the signing agent or attorney-in-fact with each SF 24.

(c) Evidence of guarantee assistance. A surety that has a guarantee of assistance from the Small Business Administration (SBA) shall submit a copy of SBA Form 990, *Surety Bond Guarantee Agreement* with each SF 24. In addition, submit a power of attorney for the surety representative identified in the agreement.

102.04 Individual Surety. Follow the requirements of FAR Clause 52.228-11 Pledges of Assets.

Complete and date the SF 28, *Affidavit of Individual Surety* after the solicitation date. The individual surety shall personally sign the SF 28. Bidders cannot serve as their own surety. See FAR 28.203 Acceptability of Individual Sureties.

After reviewing the SF 28, the surety may be requested to submit further documentation with respect to its assets, debts, or encumbrances. The information may be required to be furnished under oath. Failure of the surety to respond with the requested documentation within 7 days of receipt of the request is cause for rejection of the surety.

Any material misstatement by the surety, overstatement of assets (either as to ownership or value), or understatement of liabilities is cause for rejection of the surety. Substitution of individual sureties to support a bid bond after the bid opening will not be permitted.

Furnish documentary evidence as to the ownership and value of the assets pledged in support of the bond and details of the security interest in the assets by the individual sureties for the apparent low bidder within 14 days after the opening of bids. Failure to submit evidence within the time required will be grounds for declaring the surety unacceptable.

In addition the CO may, after reviewing the SF 28 and documentary information on the security interest and the assets pledged; request the surety to submit further information and documents with respect to the documents submitted. The CO may require such information to be furnished under oath. Failure of the surety to accept such mail or failure of the surety to respond with the requested information or documents within 7 days of receipt of the request; will be cause for rejection of the surety.

These requirements are in addition to the requirements in FAR Subpart 28.203, except where in conflict with the requirements in the FAR, in which case the FAR controls.

102.05 Public Opening of Bids. Bids will be publicly opened at the time specified in the SF 1442, *Solicitation, Offer, and Award*. Their contents will be made public information. The Government reserves the right to reject bids as set forth in the FAR, Part 14.

102.06 Performance and Payment Bonds. Follow the requirements of FAR Clause 52.228-15 Performance and Payment Bonds – Construction.

Use SF 25, *Performance Bond* and SF 25A, *Payment Bond* for submitting the bonds.

The requirements contained in Subsections 102.03 and 102.04 relating to power of attorney, evidence of guarantee assistance, and individual sureties also apply to performance and payment bonds.

Submit the documentary evidence for individual sureties at the same time as the Affidavit of Individual Surety and security interest in assets pledged. A Contractor submitting an unacceptable individual surety in satisfaction of a performance or payment bond before the issuance of the Notice to Proceed will be permitted one opportunity to substitute an acceptable surety or sureties within 7 days of receipt of notification that the surety is unacceptable.

The Government's right to direct the substitution of sureties to ensure the continuing acceptability of the bonds during the performance of the Contract according to FAR Clause 52.228-2 Additional Bond Security is not restricted.

These requirements are in addition to the requirements in FAR Subpart 28.203, except where in conflict with the requirements in the FAR, in which case the FAR controls.

Section 103. — SCOPE OF WORK

103.01 Intent of Contract. The intent of the contract is to provide for the construction and completion of the work described. The precise details of performing the work are not described, except as considered essential for the successful completion of the work. Furnish labor, material, equipment, tools, transportation, and supplies necessary to complete the work according to the contract.

103.02 Disputes. Follow the requirements of FAR Clause 52.233-1 Disputes (Alternate I).

When requesting a CO's decision on an interpretation of contract terms for the recovery of increased costs; quantify the amount and certify the amount if required by FAR Clause 52.233-1 Disputes (Alternate I). Include an explanation of the interpretation of contract terms, the contract clause under which the claim is made, supporting documentation, and adequate cost data to support the amount claimed.

103.03 Value Engineering. Follow the requirements of FAR Clause 52.248-3 Value Engineering - Construction.

Before undertaking significant expenditures, submit a written description of the value engineering change proposal (VECP) concept. Within 14 days the CO will inform the Contractor as to whether the concept appears to be viable or if the concept is unacceptable. If the CO indicates that the concept appears to be viable, prepare and submit the formal VECP proposal.

103.04 Contractor Records. Upon request, provide records related to the contract to the Government for up to 3 years after final payment or for longer periods as provided by law.

Include a provision in subcontracts at all tiers giving the Government the same rights as provided above with respect to the subcontractor's records.

103.05 Partnering. To facilitate this contract, the CO offers to participate in a formal partnership with the Contractor. This partnership draws on the strengths of each organization to identify and achieve reciprocal goals. Partnering strives to resolve problems in a timely, professional, and non-adversarial manner. If problems result in disputes, partnering encourages, but does not require, alternative dispute resolution instead of the formal claim process. The objective is effective and efficient contract performance to achieve a quality project within budget and on schedule.

Acceptance of this partnering offer by the Contractor is optional, and the partnership is bilateral.

If the partnering offer is accepted, mutually agree with the CO on the level of organizational involvement and the need for a professional to facilitate the partnering process. Engage the facilitator and other resources for key Contractor representatives and the CO to attend a partnership development and team-building workshop usually between the time of award and the Notice to Proceed. Hold additional progress meetings upon mutual agreement.

The direct cost of partnering facilities, professional facilitation, copying fees, and other miscellaneous costs directly related to partnering meetings will be shared by the Contractor and Government. Secure and pay for facilities, professional fees, and miscellaneous requirements. Submit invoices to the CO. The Government will reimburse the Contractor for 50 percent of the agreed costs incurred for the partnering process. The Government's share will not exceed $5,000.

Each party is responsible for making and paying for its own travel, lodging, and meal arrangements. No time extension for the completion of the project will be made for the use of partnering.

Section 104. — CONTROL OF WORK

104.01 Authority of the Contracting Officer (CO). The CO may delegate authority to representatives to decide on acceptability of work, progress of work, suspension of work, interpretation of the contract, and acceptable fulfillment of the contract. The term "*CO*" includes authorized representatives of the CO, including inspectors, acting within the limits of their authority as delegated by the CO.

104.02 Authority of Inspectors. Inspectors are authorized to inspect work including the preparation, fabrication, or manufacture of material for the project. The inspector is not authorized to alter or waive contract requirements, issue instruction contrary to the contract, act as foreman for the Contractor, or direct the Contractor's operations. The inspector has authority to identify non-conforming work until the issue can be referred to and decided by the CO. The inspector may take necessary action to prevent imminent and substantial risk of death or injury including stopping work.

104.03 Specifications and Drawings. Follow the requirements of FAR Clause 52.236-21 Specifications and Drawings for Construction.

(a) General. Review and submit documents required to construct the work for accuracy, completeness, and compliance with the contract for approval by the CO. Documents submitted without evidence of Contractor approval may be returned for resubmission. Time for approval starts over when documents are returned for revision or if additional information is requested by the CO. Do not perform work related to submitted documents or drawings before approval of the CO. Obtain written approval before changing or deviating from the approved drawings.

(1) Documents other than drawings. Documents other than drawings include descriptive literature, illustrations, schedules, performance and test data, and similar material submitted by the Contractor to certify or explain, in detail, specific portions of the work required by the contract. Unless otherwise indicated in the contract, submit 3 paper copies and an electronic copy for review. Allow 14 days for approval by the CO unless otherwise specified.

(2) Drawings. Drawings include:

(a) Layouts that show the relative position (vertical and horizontal as appropriate) of work to be performed;

(b) Fabrication details for manufactured items and assemblies;

(c) Installation and erection procedures;

(d) Details of post-tensioning and other systems;

(e) Detailed trench and excavation procedures that conform to OSHA requirements;

(f) Traffic control implementation drawings; and

(g) Methods for performing work near existing structures or other areas to be protected.

Show drawing dimensions in the same units as shown in the plans. Limit drawings to a maximum size of 24 by 36 inches (610 by 920 millimeters). Include on each drawing and calculation sheet, the project number, name, and other identification as shown in the contract.

Submit 3 paper sets of drawings, an electronic set of the drawings, and supporting calculations. Drawings will be reviewed in the order they are received. Allow 40 days for CO approval of railroad structure drawings and 30 days for approval of other drawings. Submit additional specific drawings for unique situations to clarify layout, construction details, or method when requested by the CO.

(b) Specific requirements for concrete and miscellaneous structures.

(1) Submit drawings for the following:

(a) Site-specific layouts for all wall types and gabion installations;

(b) Gabion and revet mattress details and installation procedures;

(c) Forms and falsework for cast-in-place non-bridge concrete structures and retaining walls less than or equal to 6 feet (1.8 meters) in height;

(d) Fabrication drawings for bridge railings and parapets;

(e) Fabrication drawings for prestressed members;

(f) Fabrication and installation drawings for expansion joint assemblies;

(g) Fabrication drawings for bearing assemblies;

(h) Construction joint location and concrete deck placement sequences not according to the plans;

(i) Erection diagrams for Soil-Corrugated Metal Structure interaction systems (multi-plate structures);

(j) Structural steel fabrication drawings;

(k) Utility hangar details;

(l) Fabrication and installation drawings for precast items; and

(m) Site-specific layouts for rockeries.

(2) Submit drawings that bear the seal and signature of a professional engineer proficient in the pertinent design field for the following:

(a) Forms and falsework for cast-in-place concrete structures greater than 6 feet (1.8 meters) in height;

(b) Shoring systems and cofferdams greater than 6 feet (1.8 meters) in height;

(c) Shoring systems that support traffic loadings;

(d) Bridge concrete forms, including deck forms; except for railings, parapets, and components less than 6 feet (1.8 meters) in height;

(e) Containment structures for bridge work;

(f) Girder erection plans;

(g) Partial demolition of structural bridge elements;

(h) Post-tensioning systems;

(i) Concrete box culvert and headwall details;

(j) Reinforced soil slopes details;

(k) Ground anchors, soil nail, rock bolt, driven pile, drilled shaft, and micropile assembly details, layout, and installation and testing procedures;

(l) MSE and tie back wall details;

(m) Alternate retaining wall details; and

(n) Details and installation procedures for proprietary wall systems.

(3) Submit drawings that bear the seal and signature of a professional engineer who is proficient in forms and falsework design and licensed in the state where the project will be constructed for the following:

(a) Falsework for structures with spans exceeding 16 feet (4.8 meters);

(b) Falsework for structures with heights exceeding 14 feet (4.3 meters);

(c) Falsework for structures where traffic, other than workers involved in constructing the structure, will travel under the structure; and

(d) Temporary bridge structures for public use.

(c) As-built drawings. Use one set of Government-provided plans exclusively for as-built drawings. Use the color "*red*" to identify changes. Use approved methods to accurately and neatly record changes. Include details and notes on additional information discovered during construction. Note additions or revisions to the location, character, and dimensions of work. Strikeout details shown that are not applicable to the completed work.

As work progresses, continuously update plan sheets to reflect the as-built details. Check and initial plan sheets that were incorporated into the completed work without change. Include the following:

(1) Title sheet.

(a) "AS-BUILT DRAWINGS" (bold text);

(b) Name of Contractor;

(c) Name of CO’s on-site representative;

(d) Project completion date;

(e) Revisions to project length;

(f) Revisions to begin and end stations of project;

(h) Revisions to index to sheets;

(i) Revisions to curve widening table;

(j) Strikeout schedules or options not awarded;

(k) A note stating "Work was constructed as designed unless otherwise noted."; and

(l) Plan notes.

(2)Typical section sheets.

(a) Revisions in dimensions;

(b) Revisions in material;

(c) Revisions in station range;

(d) Revisions to begin and end stations of project; and

(e) Strikeout schedules or options not awarded.

(3) Summary of Quantities and tabulation sheets.

(a) Revisions to quantities, locations, notes/remarks, including totals;

(b) Strikeout unused pay items;

(c) Revisions to application rates; and

(d) Revisions to location, type, end treatments, riprap, and skew on the drainage summary.

(4) Plan and profile sheets. Note additions or revisions to the location, character, and dimensions of the following items:

(a) Plan.

(1) Alignment and curve and spiral information;

(2) Construction limits;

(3) Right-of-way;

(4) Road approaches;

(5) Sub-excavation and roadway obliteration;

(6) Underdrains;

(7) Trenches and drains;

(8) Channels and ditches;

(9) Monuments and permanent references;

(10) Constructed, relocated, or encountered utilities; and

(11) Walls.

(b) Profile.

(1) Grades, elevations, and stationing of points of intersection;

(2) Equations;

(3) Culvert diameter, length, type, and stationing;

(4) Culvert extension and length of existing culvert;

(5) Walls; and

(6) Guardrail, guardwall, and end treatment.

(5) Bridge sheets. Note additions or revisions to the location, character, and dimensions of the following items:

(a) Stationing of bridge ends;

(b) Elevations including footing, bearing pads, deck, and top of walls;

(c) Pile driving record with pile length, size, type, and tip elevation;

(d) Modifications or repairs to drilled shafts or micropiles;

(e) Micropile installation records with drilling duration and observations, drill log, final location and inclination, final tip elevation, cut-off elevation, modification or repairs, grout pressures and quantities, and test records;

(f) Post-tensioning records including stressing sequence, jacking force, and duct size and layout;

(g) Construction and concrete placement sequences;

(h) Bearing details with orientation;

(i) Expansion joints including actual clearance with atmospheric temperature at time of setting joints; and

(j) Changes in plan or dimensions including changes in reinforcing.

(6) Miscellaneous sheets. Note additions or revisions to the location, character, and dimensions of the following items:

(a) Parking areas and turnouts;

(b) Curbs and sidewalks;

(c) Fencing;

(d) Landscaping and planting;

(e) Pavement markings;

(f) Signs;

(g) Permanent erosion control measures; and

(h) Plan notes.

(7) Standard and detail sheets. Note the additions or revisions to the character and dimensions of details.

Retain the drawings at the project site.

Keep the as-built drawings current and maintain a revision log of changes made. Meet with the CO to jointly review the as-built drawings and log for accuracy, completeness, and legibility before submission of each monthly invoice.

Submit the final as-built drawings and revision logs before the final inspection. Correct errors and omissions found during the final inspection and resubmit the final as-built drawings for approval within 7 days after the final inspection.

When the final as-built drawings are approved, submit the finalized set of as-built drawings and a single file, electronic color copy of the drawings. Submit the electronic copy in an approved format on a CD-R, DVD-R, or other approved electronic media. Include the latest version of the approved reader on the electronic media. Provide a resolution quality where color, text, and lines are clearly discernible.

104.04 Coordination of Contract Documents. The FAR, TAR, special contract requirements, plans, and standard specifications are contract documents. A requirement in one document is binding as though occurring in all the contract documents. The contract documents are intended to be complementary and to describe and provide for a complete contract. In case of discrepancy, calculated and shown dimensions govern over scaled dimensions. The contract documents govern in the following order:

(a) Federal Acquisition Regulations;

(b) Transportation Acquisition Regulations;

(c) Special contract requirements;

(d) Plans; and

(e) Standard specifications.

104.05 Load Restrictions. Follow the requirements of FAR Clause 52.236-10 Operations and Storage Areas.

Comply with legal load restrictions when hauling material and equipment on public roads and bridges to and from the project. A special permit does not relieve the Contractor of liability for damage resulting from the moving of material or equipment.

Unless otherwise permitted, do not operate equipment or vehicles that exceed the legal load limits over new or existing structures, or pavements within the project; except those pavements to be removed during the same construction season.

Section 105. — CONTROL OF MATERIAL

105.01 Source of Supply and Quality Requirements. Follow the requirements of FAR Clause 52.236-5 Material and Workmanship.

Select sources and submit acceptable material. Notify the CO of proposed sources before delivery to the project to expedite material inspection and testing. Do not incorporate material requiring submittal into the work until approved.

Material may be approved at the source of supply before delivery to the project. Approval of a material source does not constitute acceptance of material submitted from the source. If an approved source fails to supply acceptable material during the life of the project, further use of that source may be denied.

Submit samples of material for source quality verification testing for material required to conform to Sections 703, 704, and 705.

105.02 Material Sources.

(a) Government-provided sources. The Government will acquire the permits and rights to remove material from provided sources identified in the contract and to use such property for a plant site and stockpiles. Test reports and available historical material data will be furnished to the Contractor upon request.

Do not perform work within a source until a source development plan is approved. Allow 7 days for approval. Include the following as applicable:

(1) Requirements of written agreements;

(2) Requirements in Sections 107, 157, 204, 205, 624, and 625;

(3) Source development details;

(4) Restoration details; and

(5) Abandonment details.

Perform work necessary to produce acceptable material including work required by the approved source development plan.

The quality of material is generally acceptable. Variations in quality should be expected as it is not feasible to ascertain the quality of material for an entire deposit from exploratory samples. Determine the quantity, type of equipment, and work necessary and produce acceptable material to be incorporated into the work. Do not perform aggregate source quality tests listed in the Sampling, Testing, and Acceptance Requirements table of other Sections when using Government-provided sources. Perform quality control sampling and testing according to the approved Contractor Quality Control Plan in Section 153 and the applicable Sampling, Testing, and Acceptance Requirements tables included at the end of each Section. Allow the CO the opportunity to witness sampling and splitting of the test material.

(b) Government-provided material stockpile. The quality of the material in the stockpile has been preapproved unless otherwise noted and is considered acceptable for the application for which it has been designated. Perform quality control sampling and testing according to the approved Contractor Quality Control Plan in Section 153 and the applicable Sampling, Testing, and Acceptance Requirements table included at the end of each Section. Test results submitted will be for the Government's information only. Allow the CO the opportunity to witness sampling and splitting of the test material.

(c) Contractor-located sources. The Contractor is responsible for Contractor-located material sources, including established commercial material sources. Use sources that fulfill the contract quantity and quality requirements. Determine the quantity, type of equipment, and work necessary to select and produce an acceptable material. Secure permits and clearances for use of the source and submit copies of the documents to the CO. Follow the environmental requirements of Subsection 107.10(d). Submit available historical data indicating acceptable material can be produced from the source. Perform quality control sampling and testing according to the approved Contractor Quality Control Plan in Section 153, aggregate source quality tests, and applicable Sampling, Testing, and Acceptance Requirements table included at the end of each Section. Allow the CO the opportunity to witness sampling and splitting of the test material.

105.03 Material Source Management. Notify the CO at least 14 days before starting operations in the source. Develop and operate according to the approved source development plan for Government-provided sources or written agreement for Contractor-located sources.

Before developing a material source, measure the sediment content of bodies of water adjacent to the work area that will receive drainage from the work area. Perform erosion and sediment control according to the source development plan and the "*Storm Water Pollution Prevention Plan (SWPPP)*" or "*Erosion Control Plan*".

Do not remove material measured in-place from borrow sources or Government-provided stockpiles until initial ground survey measurements have been taken according to Subsection 204.16(b) and approved. Perform final ground survey measurements according to Subsection 204.16(b).

Dispose of rejected material in an approved manner.

105.04 Handling and Storing Material. Handle and store material to preserve its quality and fitness for the work. Stored material approved before storage may again be inspected before use in the work. Locate stored material to facilitate prompt inspection.

Use only approved portions of the right-of-way for storing material or equipment. Provide additional space as needed. Do not use private property for storage without written permission of the owner or lessee. Submit copies of agreements and documents.

Provide security for stored material.

Restore Government-provided storage sites to their original condition.

105.05 Use of Material Found in the Work. Stone, gravel, sand, or other material found in the excavation may be used for another pay item when approved. If material found in the excavation is used for another pay item, material will be paid both as excavation and as the other pay item for which it is used. Replace excavation used with acceptable material at no cost to the Government. Excavate or remove material only from within the grading limits, as indicated by the slope and grade lines.

The right to use and process material found in the work excludes the use and processing of material for nongovernment contract work, except for the disposal of waste material. If the Contractor produces or processes material from Government lands in excess of the quantities required for the contract, the Government may:

(a) Take possession of the excess material and direct its use, paying the Contractor only for the cost of production or

(b) Require removal of the material and restoration of the land to a satisfactory condition at no cost to the Government.

105.06 Material Source Restoration. Restore Government-provided sources according to the approved source development plan. Restack the unused portion of the Government-provided stockpiles upon completion of the work at no cost to the Government. Do not measure restoration of material sources for payment.

Section 106. — ACCEPTANCE OF WORK

106.01 Conformity with Contract Requirements. Follow the requirements of FAR Clause 52.246-12 Inspection of Construction.

References to standard documents and test methods of AASHTO, ASTM, GSA, and other recognized standard authorities refer to the documents and methods in effect on the date of the Invitation for Bids (IFB) or Request for Proposal (RFP).

Use the FLH, *Field Materials Manual (FMM), Appendix B: FLH Test Methods* in effect on the date of the IFB or RFP. Electronic copies of the FLH Test Methods and FHWA forms can be downloaded from:

http://flh.fhwa.dot.gov/resources/manuals/fmm/

Specification limits, tolerances, test results, and related calculations are according to ASTM E29, Absolute Method.

Perform work to the lines, grades, cross-sections, dimensions, and processes or material requirements shown in the contract.

Incorporate manufactured material into the work according to the manufacturer's recommendations or to these specifications, whichever is stricter.

When standard manufactured items are specified (such as fence, wire, plates, rolled shapes, and pipe conduits that are identified by gauge, density, or section dimensions) the identification will be considered to be nominal masses or dimensions. Unless specific contract tolerances are noted, established manufacturing tolerances will be accepted.

Plan dimensions and contract specification values are the values to be strived for and complied with as the design values from which deviations are allowed. Perform work and provide material that is uniform in character and reasonably close to the prescribed value or within the specified tolerance range. The purpose of a tolerance range is to accommodate occasional minor variations from the median zone that are unavoidable for practical reasons.

The Government may inspect, sample, or test work before final acceptance of the project. If the Government tests work, copies of test reports are furnished to the Contractor upon request. Government tests may or may not be performed at the work site.

If Government testing is performed on work, the result will be used for acceptance purposes under Subsection 106.04.

Do not rely on the availability of Government test results for process control.

Acceptable work conforming to the contract will be paid for at the contract unit bid price. Four methods of determining conformity and accepting work are described in Subsections 106.02 through 106.05. The primary method of acceptance is specified in each Section of work, but work may be rejected if it is found not to comply with the contract.

For work that is evaluated and accepted under Subsection 106.05, if Contractor testing and inspection is verified by the Government, the Contractor's results may be used by the Government to evaluate work for acceptance. Contractor data will be verified using the F- and t-test statistics in comparison to Government test results at a significance level of 0.01. If the Contractor's data is not verified and the CO determines it to be appropriate, the Government will perform tests associated for that discrete portion of work. In this situation, the Government test results will control in determining the acceptability and pay factor of the work.

Remove and replace work that does not conform to the contract, or to prevailing industry standards where no specific contract requirements are noted, at no cost to the Government.

As an alternative to removal and replacement, the Contractor may submit a written request to:

(a) Have the work accepted at a reduced price; or

(b) Perform corrective measures to bring the work into conformity.

Include supporting rationale and documentation in the request. Include references or data justifying the proposal based on an evaluation of test results, effect on service life, value of material or work, quality, aesthetics, and other tangible engineering basis. The CO will determine disposition of the nonconforming work.

106.02 Visual Inspection. Acceptance is based on visual inspection of the work for compliance with the contract and prevailing industry standards.

106.03 Certification. For material manufactured off-site, use a manufacturer with an ISO 9000 certification or an effective testing and inspection system. Require the manufacturer to clearly mark the material or packaging with a unique product identification or specification standard to which it is produced.

Other than references in or to the FAR or Federal Law, when these Standard Specifications or Special Contract Requirements reference certifications, certificates or certified documents, equipment or individuals; these references refer to documentation of non-regulatory, peripheral contract requirements that are required to be validated by an individual or organization having unique knowledge or qualifications to perform such validation.

Check certifications before incorporating the material into the work to ensure that the requirements of the contract have been met. Mark the certifications with the following information:

- Project number and name;
- Pay item number and description;
- Contractor's signature; and
- Date.

Material accepted by certification may be sampled and tested. If material is determined not to conform with the contract, the material will be rejected whether in place or not.

One of the following certifications may be required:

(a) Production certification. Material requiring a production certification is identified in the Acceptance Subsection of each Section. Submit a production certification from the manufacturer for each shipment of material. Include the following:

(1) Date and place of manufacture;

(2) Lot number or other means of cross-referencing to the manufacturer's inspection and testing system; and

(3) Substantiating evidence that the material conforms to the contract quality requirements as required by FAR 46.105(a)(4), including the following:

(a) Test results on material from the same lot and documentation of the inspection and testing system;

(b) A statement from the manufacturer that the material complies with the contract; and

(c) Manufacturer's signature or other means of demonstrating accountability for the certification.

(b) Commercial certification. Submit one commercial certification for similar material from the same manufacturer.

A commercial certification is a manufacturer's or Contractor's representation that the material complies with the contract. The representation may be labels, catalog data, stamped specification standards, or supplier's certifications indicating the material is produced to a commercial standard or specification.

106.04 Measured or Tested Conformance. Perform necessary measurements and tests to ensure work complies with the contract.

Use prevailing industry standards in the absence of contract requirements or tolerances.

Submit measurements, tests, and supporting data for acceptance.

106.05 Statistical Evaluation of Work and Determination of Pay Factor. Statistical evaluation of work is a method of analyzing inspection or test results to determine conformity with the contract. The work will be accepted as follows:

(a) General. For work evaluated based on statistical evaluation, both the Government and Contractor assume some risk.

The Government's risk is the probability that work of a rejectable quality level is accepted. The Contractor's risk is either the probability that work produced at an acceptable quality level (AQL) is rejected (α) or the probability that the work produced at the AQL is accepted at less than the contract unit bid price (α_{100}).

Acceptable quality level is the lowest percentage of work within the specification limits that is considered acceptable for payment at contract unit bid price. There are two categories:

- Category I is based on an AQL of 95 percent.
- Category II is based on an AQL of 90 percent.

In both cases, the Contractor's risk (α_{100}) is 5 percent and the risk of rejection (α) is significantly lower.

As an incentive to produce uniform quality work and to offset the Contractor's risk, a final payment greater than the contract unit bid price may be obtained under certain conditions.

The quality characteristics to be evaluated, sampling frequency, sampling location, test methods, and category are listed in the Acceptance Subsection of each Section. The following applies:

(1) Lot size. A lot is a discrete quantity of work to which the statistical evaluation procedure is applied. A lot normally represents the total quantity of work produced. More than one lot may occur if changes in the target values, material sources, or job-mix formula are requested in writing and approved.

(2) Sampling frequency. The frequency rate shown normally requires at least 5 samples. The minimum required to perform a statistical evaluation is 3 samples. The maximum obtainable pay factor with 3, 4, or 5 samples is 1.01. At least 8 samples are required to obtain a 1.05 pay factor.

If the sampling frequencies and quantity of work would otherwise result in fewer than 8 samples; submit a written request to increase the sampling frequency to provide for at least 8 samples. Submit the request to increase the sampling frequency at least 48 hours before beginning production. An increase in the sampling frequency may result in a reduced pay factor.

(3) Sampling location. The exact location of sampling will be determined by the CO based on random numbers.

(4) Specification limits. The specification limits for the quality characteristics are listed in the contract for the work in question.

(b) Acceptance. The work in the lot will be paid for at a final pay factor when all inspections or test results are completed and evaluated.

Before determining the final pay factor, the work may be incorporated into the project provided the current pay factor does not fall below 0.90. If a lot is concluded with fewer than 3 samples, the material will be evaluated under Subsection 106.04.

If the current pay factor of a lot falls below 0.90, end production. Production may resume after the Contractor takes effective and acceptable actions to improve the quality of the production.

A lot containing an unsatisfactory percentage of non-specification material (less than 1.00 pay factor) is accepted provided the lowest single pay factor has not fallen into the reject portion of Table 106-2.

A lot containing an unsatisfactory percentage of non-specification material with the lowest single pay factor falling into the reject portion of Table 106-2 is rejected. Remove rejected material from the work.

When approved, it is permissible to voluntarily remove non-specification material and replace it with new material to avoid or minimize a pay factor of less than 1.00. New material will be sampled, tested, and evaluated according to this Subsection.

Any quantity of material may be rejected based on visual inspection or test results. Do not incorporate rejected material in the work. The results of tests run on rejected material will be excluded from the lot.

(c) Statistical evaluation. The Variability-Unknown/Standard Deviation Method will be used to determine the estimated percentage of the lot that is within specification limits.

The estimated percentage of work that is within the specification limits for each quality characteristic will be determined as follows:

(1) Calculate the arithmetic mean ($\bar{x}$) of the test values: $\bar{x} = \frac{\sum x}{n}$

where: $\sum$ = summation of:

x = individual test value
n = total number of test values

(2) Calculate the standard deviations:

$$s = \sqrt{\frac{n\sum(x^2) - (\sum x)^2}{n(n-1)}}$$

where: $\sum(x^2)$ = summation of the squares of individual test values

$(\sum x)^2$ = summation of the individual test values squared

(3) Calculate the upper quality index (Q_U): $Q_U = \frac{USL - \bar{x}}{s}$

where: *USL* = upper specification limit

Note: The *USL* is equal to the contract specification limit or the target value plus the allowable deviation.

(4) Calculate the lower quality index (Q_L): $Q_L = \frac{\bar{x} - LSL}{s}$

where: *LSL* = lower specification limit

Note: The *LSL* is equal to the contract specification limit or the target value minus the allowable deviation.

(5) From Table 106-1, determine P_U (the estimated percentage of work within the *USL*). P_U corresponds to a given Q_U. If a *USL* is not specified, P_U is 100.

(6) From Table 106-1, determine P_L (the estimated percentage of work within the lot within the *LSL*). P_L corresponds to a given Q_L. If an *LSL* is not specified, P_L is 100.

(7) Calculate the total estimated percentage of work within the *USL* and *LSL*:

$P_U + P_L - 100$

(8) Repeat steps 1 through 7 for each quality characteristic listed for statistical evaluation.

Table 106-1
Estimated Percent of Work Within Specification Limits

Estimated Percent within Specification Limits (P_U or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L								
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14
100	1.16	1.49	1.72	1.88	1.99	2.07	2.13	2.20	2.28
99	-	1.46	1.64	1.75	1.82	1.88	1.91	1.96	2.01
98	-	1.43	1.58	1.66	1.72	1.75	1.78	1.81	1.84
97	1.15	1.40	1.52	1.59	1.63	1.66	1.68	1.71	1.73
96	-	1.37	1.47	1.52	1.56	1.58	1.60	1.62	1.64
95	1.14	1.34	1.42	1.47	1.49	1.51	1.52	1.54	1.55
94	-	1.31	1.38	1.41	1.43	1.45	1.46	1.47	1.48
93	1.13	1.28	1.33	1.36	1.38	1.39	1.40	1.41	1.41
92	1.12	1.25	1.29	1.31	1.33	1.33	1.34	1.35	1.35
91	1.11	1.22	1.25	1.27	1.28	1.28	1.29	1.29	1.30
90	1.10	1.19	1.21	1.23	1.23	1.24	1.24	1.24	1.25
89	1.09	1.16	1.18	1.18	1.19	1.19	1.19	1.19	1.20
88	1.07	1.13	1.14	1.14	1.15	1.15	1.15	1.15	1.15
87	1.06	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.11
86	1.04	1.07	1.07	1.07	1.07	1.06	1.06	1.06	1.06
85	1.03	1.04	1.03	1.03	1.03	1.03	1.02	1.02	1.02
84	1.01	1.01	1.00	0.99	0.99	0.99	0.99	0.98	0.98
83	0.99	0.98	0.97	0.96	0.95	0.95	0.95	0.95	0.94
82	0.97	0.95	0.93	0.92	0.92	0.92	0.91	0.91	0.91
81	0.95	0.92	0.90	0.89	0.88	0.88	0.88	0.87	0.87
80	0.93	0.89	0.87	0.86	0.85	0.85	0.84	0.84	0.84
79	0.91	0.86	0.84	0.82	0.82	0.81	0.81	0.81	0.80
78	0.88	0.83	0.81	0.79	0.79	0.78	0.78	0.77	0.77
77	0.86	0.80	0.77	0.76	0.75	0.75	0.74	0.74	0.74
76	0.83	0.77	0.74	0.73	0.72	0.72	0.71	0.71	0.70
75	0.81	0.74	0.71	0.70	0.69	0.69	0.68	0.68	0.67
74	0.78	0.71	0.68	0.67	0.67	0.65	0.65	0.65	0.64
73	0.75	0.68	0.65	0.64	0.63	0.62	0.62	0.62	0.61
72	0.73	0.65	0.62	0.61	0.60	0.59	0.59	0.59	0.58
71	0.70	0.62	0.59	0.58	0.57	0.57	0.56	0.56	0.55
70	0.67	0.59	0.56	0.55	0.54	0.54	0.53	0.53	0.52
69	0.64	0.56	0.53	0.52	0.51	0.51	0.50	0.50	0.50
68	0.61	0.53	0.50	0.49	0.48	0.48	0.48	0.47	0.47
67	0.58	0.50	0.47	0.46	0.45	0.45	0.45	0.44	0.44
66	0.55	0.47	0.45	0.43	0.43	0.42	0.42	0.42	0.41
65	0.51	0.44	0.42	0.40	0.40	0.39	0.39	0.39	0.38
64	0.48	0.41	0.39	0.38	0.37	0.37	0.36	0.36	0.36
63	0.45	0.38	0.36	0.35	0.34	0.34	0.34	0.33	0.33
62	0.41	0.35	0.33	0.32	0.32	0.31	0.31	0.31	0.30
61	0.38	0.30	0.30	0.30	0.29	0.28	0.28	0.28	0.28
60	0.34	0.28	0.28	0.25	0.25	0.25	0.25	0.25	0.25
59	0.31	0.27	0.25	0.23	0.23	0.23	0.23	0.23	0.23
58	0.30	0.25	0.23	0.20	0.20	0.20	0.20	0.20	0.20
57	0.25	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.20	0.18	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.15	0.13	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.10	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

If the value of Q_U or Q_L does not correspond to a value in the table, use the next lower Q value. If Q_U or Q_L are negative values, P_U or P_L is equal to 100 minus the table value for P_U or P_L.

Table 106-1 (continued)
Estimated Percent of Work Within Specification Limits

Estimated Percent within Specification Limits (P_U or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L					
	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to ∞
100	2.34	2.39	2.44	2.48	2.51	2.56
99	2.04	2.07	2.09	2.12	2.14	2.16
98	1.87	1.89	1.91	1.93	1.94	1.95
97	1.75	1.76	1.78	1.79	1.80	1.81
96	1.65	1.66	1.67	1.68	1.69	1.70
95	1.56	1.57	1.58	1.59	1.59	1.60
94	1.49	1.50	1.50	1.51	1.51	1.52
93	1.42	1.43	1.43	1.44	1.44	1.44
92	1.36	1.36	1.37	1.37	1.37	1.38
91	1.30	1.30	1.31	1.31	1.31	1.31
90	1.25	1.25	1.25	1.25	1.26	1.26
89	1.20	1.20	1.20	1.20	1.20	1.20
88	1.15	1.15	1.15	1.15	1.15	1.15
87	1.11	1.11	1.11	1.11	1.11	1.11
86	1.06	1.06	1.06	1.06	1.06	1.06
85	1.02	1.02	1.02	1.02	1.02	1.02
84	0.98	0.98	0.98	0.98	0.98	0.98
83	0.94	0.94	0.94	0.94	0.94	0.94
82	0.91	0.90	0.90	0.90	0.90	0.90
81	0.87	0.87	0.87	0.87	0.87	0.87
80	0.83	0.83	0.83	0.83	0.83	0.83
79	0.80	0.80	0.80	0.80	0.80	0.79
78	0.77	0.76	0.76	0.76	0.76	0.76
77	0.73	0.73	0.73	0.73	0.73	0.73
76	0.70	0.70	0.70	0.70	0.70	0.70
75	0.67	0.67	0.67	0.67	0.67	0.66
74	0.64	0.64	0.64	0.64	0.64	0.63
73	0.61	0.61	0.61	0.61	0.61	0.60
72	0.58	0.58	0.58	0.58	0.58	0.57
71	0.55	0.55	0.55	0.55	0.55	0.54
70	0.52	0.52	0.52	0.52	0.52	0.52
69	0.49	0.49	0.49	0.49	0.49	0.49
68	0.47	0.46	0.46	0.46	0.46	0.46
67	0.44	0.44	0.43	0.43	0.43	0.43
66	0.41	0.41	0.41	0.41	0.41	0.40
65	0.38	0.38	0.38	0.38	0.38	0.38
64	0.36	0.35	0.35	0.35	0.35	0.35
63	0.33	0.33	0.33	0.33	0.33	0.32
62	0.30	0.30	0.30	0.30	0.30	0.30
61	0.28	0.28	0.28	0.28	0.28	0.28
60	0.25	0.25	0.25	0.25	0.25	0.25
59	0.23	0.23	0.23	0.23	0.23	0.23
58	0.20	0.20	0.20	0.20	0.20	0.20
57	0.18	0.18	0.18	0.18	0.18	0.18
56	0.15	0.15	0.15	0.15	0.15	0.15
55	0.13	0.13	0.13	0.13	0.13	0.13
54	0.10	0.10	0.10	0.10	0.10	0.10
53	0.08	0.08	0.08	0.08	0.08	0.08
52	0.05	0.05	0.05	0.05	0.05	0.05
51	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00

If the value of Q_U or Q_L does not correspond to a value in the table, use the next lower Q value. If Q_U or Q_L are negative values, P_U or P_L is equal to 100 minus the table value for P_U or P_L.

Table 106-2 Pay Factors

PAY FACTOR		Minimum Required Percent of Work Within Specification Limits for a Given Pay Factor $(P_U + P_L) - 100$														
Category		n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to ∞
I	II															
1.05							100	100	100	100	100	100	100	100	100	100
1.04						100	99	97	95	96	96	96	97	97	97	97
1.03					100	98	96	94	92	93	93	94	95	95	96	96
1.02					99	97	94	91	89	90	91	92	93	93	94	94
1.01		100	100	100	98	95	92	89	87	88	89	90	91	92	92	93
1.00		69	75	78	80	82	83	84	85	86	87	88	89	90	91	92
0.99		66	72	76	78	80	81	82	83	84	85	86	87	89	90	91
0.98		64	70	74	76	78	79	80	81	82	84	85	86	87	88	90
0.97		63	68	72	74	76	77	78	79	81	82	83	84	86	87	88
0.96		61	67	70	72	74	75	76	78	79	81	82	83	84	86	87
0.95	1.00	59	65	68	71	72	74	75	76	78	79	80	82	83	84	86
0.94	0.99	58	63	67	69	71	72	73	75	76	78	79	80	82	83	85
0.93	0.98	57	62	65	67	69	71	72	73	75	76	78	79	80	82	84
0.92	0.97	55	60	63	66	68	69	70	72	73	75	76	78	79	81	82
0.91	0.96	54	59	62	64	66	68	69	70	72	74	75	76	78	79	81
0.90	0.95	53	57	61	63	65	66	67	69	71	72	74	75	77	78	80
0.89	0.94	51	56	59	62	63	65	66	68	69	71	72	74	75	77	79
0.88	0.93	50	55	58	60	62	64	65	66	68	70	71	73	74	76	78
0.87	0.92	49	53	57	59	61	62	63	65	67	68	70	71	73	75	77
0.86	0.91	48	52	55	58	59	61	62	64	66	67	69	70	72	74	76

If the value of $(P_U + P_L) - 100$ does not correspond to a $(P_U + P_L) - 100$ value in this table, use the next smaller $(P_U + P_L) - 100$ value.

Table 106-2 Pay Factors (continued)

PAY FACTOR		Minimum Required Percent of Work Within Specification Limits for a Given Pay Factor ($P_U + P_L$) – 100														
Category		n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to ∞
I	II															
0.85	0.90	46	51	54	56	58	60	61	62	64	66	67	69	71	72	75
0.84	0.89	45	49	53	55	57	58	60	61	63	65	66	68	70	71	73
0.83	0.88	44	48	51	54	56	57	58	60	62	64	65	67	69	70	72
0.82	0.87	43	47	50	53	54	56	57	59	61	62	64	66	67	69	71
0.81	0.86	41	46	49	51	53	55	56	58	59	61	63	64	66	68	70
0.80	0.85	40	44	48	50	52	54	55	56	58	60	62	63	65	67	69
0.79	0.84	39	43	46	49	51	52	54	55	57	59	61	62	64	66	68
0.78	0.83	38	42	45	48	50	51	52	54	56	58	59	61	63	65	67
0.77	0.82	36	41	44	46	48	50	51	53	55	57	58	60	62	64	66
0.76	0.81	35	39	43	45	47	49	50	52	54	56	57	59	61	63	65
0.75	0.80	33	38	42	44	46	48	49	51	53	54	56	58	60	62	64
REJECT	0.79	32	37	40	43	45	47	48	49	52	53	55	57	59	60	63
	0.78	30	36	39	42	44	45	47	48	50	52	54	56	57	59	62
	0.77	28	34	38	41	43	44	46	47	49	51	53	55	56	58	61
	0.76	27	33	37	39	42	43	45	46	48	50	52	53	55	57	60
	0.75	25	32	36	38	40	42	43	45	47	49	51	52	54	56	59
Values Less Than Those Shown Above																

If the value of ($P_U + P_L$) – 100 does not correspond to a ($P_U + P_L$) – 100 value in this table, use the next smaller ($P_U + P_L$) – 100 value.

(d) Pay factor determination (value of the work). The pay factor for a lot will be determined as follows:

(1) The pay factor for each quality characteristic will be determined from Table 106-2 using the total number of test values and the total estimated percentage within the specification limits from Subsection 106.05(c)(7).

(2) When all quality characteristics for a lot are Category I, the lot pay factor is based on the lowest single pay factor for any Category I quality characteristic. The maximum obtainable pay factor is 1.05.

(3) When quality characteristics for a lot are both Category I and II, the lot pay factor is based on the following:

(a) When all Category II quality characteristics are 1.00, the lot payment is based on the lowest single pay factor for all Category I characteristics. The maximum obtainable pay factor is 1.05.

(b) When any Category II quality characteristic is less than 1.00, the lot payment is based on the lowest single pay factor for any Category I or II quality characteristic.

(4) When all quality characteristics for a lot are Category II, the lot pay factor is based on the lowest single pay factor for any Category II quality characteristic. The maximum obtainable pay factor is 1.00.

(5) Adjusted payment for material in a lot will be made at a price determined by multiplying the contract unit bid price by the lot pay factor as determined above, or as described in the Payment Subsection of the Section ordering the work.

106.06 Inspection at the Plant. Work may be inspected at the point of production or fabrication. Manufacturing plants may be inspected for compliance with specified manufacturing methods. Material samples may be obtained for laboratory testing for compliance with quality requirements. Allow full entry at all times to the parts of the plant producing the work.

106.07 Partial and Final Acceptance. Maintain the work during construction and until the project is accepted. Repair damage caused by the Contractor before final acceptance of the entire project at no cost to the Government. See FAR Clause 52.236-11 Use and Possession Prior to Completion.

(a) Partial acceptance. When a segment of the project is completed, a final inspection of that segment may be requested. If the segment is complete and in compliance, it may be accepted. If accepted, the CO may relieve the Contractor of further responsibility for maintaining accepted work.

When public traffic is accommodated through construction and begins using sections of roadway as they are completed, continue maintenance of such sections until final acceptance.

(b) Final acceptance. Notify the CO when the entire project is complete to schedule an inspection. If work is determined to be complete, the inspection will constitute the final inspection. The Contractor will be notified in writing of final acceptance as of the date of the final inspection. Final acceptance relieves the Contractor of further responsibility for the maintenance of the project.

If the inspection discloses unsatisfactory work, the CO will provide to the Contractor a list of the work that is incomplete or requires correction. Immediately complete or correct the work. Submit notification when the work has been completed as provided above.

Section 107. — LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01 Laws to be Observed. Follow the requirements of FAR Clause 52.236-7 Permits and Responsibilities.

Comply with applicable laws, ordinances, safety codes, regulations, orders, and decrees. Protect and indemnify the Government and its representatives against claim or liability arising from or based on the alleged violation of the same.

Comply with permits and agreements obtained by the Government for performing the work that is included in the contract. Obtain additional permits or agreements and modifications to Government-obtained permits or agreements that are required by the Contractor's methods of operation. Submit copies of permits and agreements.

107.02 Protection and Restoration of Property and Landscape. Follow the requirements of FAR Clause 52.236-9 Protection of Existing Vegetation, Structures, Equipment, Utilities, and Improvements.

Preserve public and private property. Protect monuments established for perpetuating horizontal, vertical, cadastral, or boundary control. When necessary to destroy a monument, reestablish the monument according to applicable state statute or by the direction of the agency or individual who established the monument.

Do not disturb the area beyond the construction limits. Replace trees, shrubs, or vegetated areas damaged by construction operations as directed and at no cost to the Government. Remove damaged limbs of existing trees by an approved arborist.

Do not excavate, remove, damage, alter, or deface archeological or paleontological remains or specimens. Control the actions of employees and subcontractors on the project to ensure that protected sites are not disturbed or damaged. Should these items be encountered, suspend operations at the discovery site, notify the CO and continue operations in other areas. The CO will inform the Contractor when operations may resume at the discovery site.

When utilities are to be relocated or adjusted, the Government will notify utility owners affected by the relocations or adjustments.

Before beginning work in an area, contact the local utility locating service to mark the utilities. Protect utilities from construction operations. Cooperate with utility owners to expedite the relocation or adjustment of their utilities to minimize interruption of service and duplication of work.

If utility services are interrupted as a result of damage by the construction, immediately notify the utility owner, the CO, and other proper authorities. Cooperate with them until service is restored. Do not work around fire hydrants until provisions for continued service are made and approved by the local fire authority.

Notify the CO if utility work is required. Compensation for the work will be provided under applicable clauses of the contract. Satisfactorily repair damage due to the fault or negligence of the Contractor at no cost to the Government.

Repair of damage to underground utilities not shown in the plans or identified before construction, and not caused by the fault or negligence of the Contractor will be paid for by the Government.

107.03 Bulletin Board. Furnish a weatherproof bulletin board of suitable size and construction for continuous display of posters and other information required by the contract. Erect and maintain the bulletin board at a conspicuously accessible location on the project and remove and dispose of it after project final acceptance.

Display the following documents on the bulletin board:

(a) Equal Employment Opportunity Commission (EEOC), *Equal Opportunity Is The Law* poster according to FAR Clause 52.222-26 Equal Opportunity;

(b) FHWA Form 1022, *Notice* that the project is subject to Title 18, U.S. Criminal Code, Section 1020 poster;

(c) Department of Labor, Wage and Hour Division (WHD), WHD 1321, *Employee Rights Under The Davis-Bacon Act* poster (regarding proper pay);

(d) Department of Labor, OSHA, *Job Health and Safety: It's The Law* poster, according to Title 29, Code of Federal Regulations, Part 1903;

(e) "General Wage Decision" contained in the contract;

(f) Company equal employment opportunity policy, according to FAR Clause 52.222-27, Affirmative Action Compliance Requirements for Construction;

(g) Emergency telephone numbers (in areas where 911 is not available), according to Title 29, Code of Federal Regulation, Part 1926.50(f);

(h) WHD Publication, *Employee Rights and Responsibilities Under the Family and Medical Leave Act* poster according to Title 29, Code of Federal Regulation, Part 825.300(a);

(i) WHD 1462, *Employee Polygraph Protection Act* poster; and

(j) National Labor Relations Board (NLRA), *Employee Rights Under The National Labor Relations Act* poster according to Executive Order 13496.

107.04 Railroad Protection. The Government will obtain the necessary permits and agreements from the railroad for specified work for relocating railroads or for work at railroad crossings. Make arrangements for other work that, due to the method of operation, may also impact the railroad. Submit copies of permits and agreements.

Do not interfere with railroad operations. If the construction damages railroad property, reimburse the railroad for damages, or at the railroad's option, repair the damage at no cost to the Government.

Do not cross railroad tracks, with vehicles or equipment, except at existing and open public grade crossings or railroad approved temporary grade crossings. If there is a need for a temporary grade crossing, make the necessary arrangements with the railroad for its construction, protection, and removal. Reimburse the railroad for temporary grade crossing work or at the railroad's option, perform the work.

107.05 Responsibility for Damage Claims. Indemnify and hold harmless the Government, its employees, and its consultants from suits; actions; or claims brought for injuries or damage received or sustained by a person, persons, or property resulting from the construction operations or arising out of the negligent performance of the contract.

Procure and maintain until final acceptance of the contract, liability insurance of the types and limits specified below. Obtain insurance from companies authorized to do business in the appropriate state. Ensure the insurance covers operations under the contract whether performed by the Contractor or by subcontractors.

Before work begins, submit "*certificates of insurance*" certifying that the policies will not be changed or canceled until written notice has been given to the Government. Insurance coverage in the minimum amounts set forth below does not relieve the Contractor of liability in excess of the coverage.

Carry insurance conforming to the following minimums:

(a) Worker's compensation insurance. Minimum required by law.

(b) Comprehensive or commercial general liability insurance.

(1) Personal injury and property damage coverage;

(2) Contractual liability coverage;

(3) Completed operations liability coverage;

(4) $1,000,000 combined single limit for each occurrence; and

(5) $2,000,000 general aggregate limit.

(c) Automobile liability insurance. $1,000,000 combined single limit for each occurrence.

107.06 Contractor's Responsibility for Work. Assume responsibility for all work until final acceptance, except as provided in Subsection 106.07. This includes periods of suspended work. Protect the work against injury, loss, or damage from all causes whether arising from the execution or non-execution of the work.

Maintain public traffic according to Section 156.

Rebuild, repair, restore, and make good losses, injuries, or damages to any portion of the work. This includes losses, injuries, or damages caused by vandalism, theft, accommodation of public traffic, and weather that occurs during the contract.

The Government will only be responsible for costs attributable to repairing or replacing damaged work caused by declared enemies and terrorists of the Government and cataclysmic natural phenomenon (such as tornadoes, earthquakes, major floods, and other officially declared natural disasters). The Government will not be responsible for delay costs, impact costs, or extended overhead costs.

107.07 Furnishing Right-of-Way. The Government will obtain right-of-way.

107.08 Sanitation, Health, and Safety. Follow the requirements of FAR Clause 52.236-13 Accident Prevention.

Observe rules and regulations of Federal, state, and local health officials. Do not allow workers to work in surroundings or under conditions that are unsanitary, hazardous, or dangerous.

Admit OSHA inspectors or other legally responsible officials involved in safety and health administration to the project work site upon presentation of proper credentials.

Report accidents on forms furnished by the Government or with prior approval, on forms used to report accidents to other agencies or insurance carriers. Maintain an OSHA Form 300, *Log of Work-Related Injuries and Illnesses* and make it available for inspection.

Install a reverse signal alarm audible above the surrounding noise level on motorized vehicles having an obstructed view and on earth-moving and compaction equipment.

107.09 Legal Relationship of the Parties. In the performance of the contract, the Contractor is an independent contractor. The Contractor's independent contractor status does not limit the Government's general rights under the contract. No Government employee or a business organization owned or substantially owned or controlled by one or more Government employees may be a Contractor.

107.10 Environmental Protection.

(a) Federal Water Pollution Control Act (Clean Water Act) 33 USC § 1251 et seq.

(1) Do not operate equipment or discharge material within the boundaries of wetlands and the waters of the United States as defined by the federal and state regulatory agencies. Permits are issued by the U.S. Army Corps of Engineers according to 33 USC § 1344 and delegated by the agency having jurisdiction. If an unauthorized discharge occurs:

(a) Prevent further contamination;

(b) Notify appropriate authorities and the CO; and

(c) Mitigate damages.

(2) Construct and maintain barriers in work areas and in material sources to prevent sediment, petroleum products, chemicals, and other liquids and solids from entering wetlands or waters of the United States. Remove and properly dispose of barrier collected material.

(3) Do not revise terms or conditions of permits without the approval of the issuing agency.

(b) Oil and hazardous substances. Submit a "*Spill Prevention, Control, and Countermeasure (SPCC) Plan*" if required at least 2 days before beginning work.

If a SPCC plan is not required, submit a hazardous spill plan at least 2 days before beginning work. Describe preventative measures including the location of refueling and storage facilities and the handling of hazardous material. Describe actions to be taken in case of a spill.

Do not use equipment with leaking fluids. Repair equipment fluid leaks immediately. Keep absorbent material manufactured for containment and cleanup of hazardous material on the job site.

Notify the CO of hazardous spills.

(c) Dirt, plant, and foreign material. Remove dirt, plant, and foreign material from vehicles and equipment before mobilizing to work site. Prevent introduction of noxious weeds and non-native plant species into the work site. Follow applicable Federal land management agency requirements and state requirements. Maintain cleaning and inspection records.

(d) Clearances for Contractor-selected, noncommercial areas. Contractor-selected, noncommercial areas include material sources, disposal sites, waste areas, haul roads, and staging areas located outside project construction limits and permitted commercial areas. Permitted commercial areas are enterprises or developed areas providing same type material or use over the last 2 years with appropriate permits.

Before using a Contractor-selected, noncommercial areas, submit the following:

(1) Description, schedule, and map of area.

(2) Documentation of compliance with applicable laws and regulations.

(3) Owner approval for the area use. When use of Federal land is proposed, submit an approval letter or special use permit from the applicable Federal land management agency.

(4) Legal c**ompliance for the area use.** Submit documentation showing compliance with applicable tribal, state and local laws including permits or other approvals issued for the area use.

107.11 Protection of Forests, Parks, and Public Lands. Comply with regulations of the state fire marshal, conservation commission, Federal land management agency, or other authority having jurisdiction governing the protection of land including or adjacent to the project.

Section 108. — PROSECUTION AND PROGRESS

108.01 Commencement, Prosecution, and Completion of Work. Follow the requirements of FAR Clause 52.211-10 Commencement, Prosecution, and Completion of Work.

A preconstruction conference will be held after the contract is awarded and before beginning work. Seven days before the preconstruction conference, submit copies of the preliminary construction schedule according to Section 155.

108.02 Subcontracting. Follow the requirements of FAR Clause 52.219-14 Limitations on Subcontracting, FAR Clause 52.222-11 Subcontracts (Labor Standards), and FAR Clause 52.236-1 Performance of Work by the Contractor.

Subcontracting does not relieve the Contractor of liability and responsibility under the contract and does not create any contractual relation between subcontractors and the Government. The Contractor is liable and responsible for actions or lack of action of subcontractors.

Within 14 days of subcontract award, submit an SF 1413, *Statement and Acknowledgment* with Part I completed. Complete other forms that may be provided by the Government to show the work subcontracted and the total dollar amount of the subcontract. For subcontracts involving on-site labor, require the subcontractor to complete Part II of the SF 1413 and complete other forms that may be provided by the Government. Submit a separate statement documenting the cumulative amount of on-site subcontracts to date as a percentage of the original contract amount. Submit this information on subcontracts at lower tiers.

In FAR Clause 52.219-8, Utilization of Small Business Concerns and FAR Clause 52.232-27 Prompt Payment for Construction Contracts, the term "*subcontracts*" includes on-site and off-site work and supply contracts.

For contracts in which FAR Clause 52.219-14 Limitations on Subcontracting applies, the percentage of work performed by the Contractor will be computed as the cost of the contract work performed by the Contractor's employees, not including the cost of material, divided by the cost of all contract work, not including the cost of material. For contracts on which FAR Clause 52.236-1 Performance of Work applies, the percentage of work performed by the Contractor will be computed as the cost of the contract work performed on-site by the Contractor's employees divided by the total cost of the contract.

108.03 Determination and Extension of Contract Time. Follow the requirements of FAR Clause 52.211-10 Commencement, Prosecution, and Completion of Work.

(a) Definitions.

(1) Time Impact Analysis. The procedure by which the Contractor demonstrates the effect of specific time impacts on the overall construction schedule. Time impacts may result in an increase or decrease in contract time.

(2) Float. The amount of time between when an activity "*can start*" (the early start) and when an activity "*must start*" (the late start).

(b) Time Impact Analysis. Comply with the applicable contract clauses when requesting a time extension. Notify the CO in writing within 7 days after identifying a time impact.

Submit a time impact analysis and revised construction schedule within 14 days after the end of the time impact event for which notice has been given. Include the following:

(1) A title page or header block with:

(a) Contract number;

(b) Project number and name;

(c) Contractor name;

(d) Current fixed completion date;

(e) Date of submittal; and

(f) Consecutive number for each analysis.

(2) State the impact that requires a Time Impact Analysis:

(a) CO proposed or directed Contract Modification;

(b) Contractor proposed Contract Modification;

(c) Weather delay; or

(d) Other Government caused delay.

(3) A copy of the most current approved schedule existing before the impact.

(4) A detailed narrative describing each impact event. Describe impacts to each affected activity in the construction schedule. Include the following:

(a) Contract clauses under which the request is being made;

(b) Cause of the impact;

(c) Start date of the impact;

(d) Duration of the impact; and

(e) Methods to be employed to re-sequence or reschedule the work to mitigate the impact. Discuss the feasibility of re-sequencing future work to mitigate delay. Re-sequencing or rescheduling of work will be at no cost to the Government. Include corresponding rationale and assumptions of measures which increase the cost of mitigating the impact.

(5) A revised construction schedule to show the impact of the activities identified, including re-sequencing which would mitigate the delay.

(c) Time extensions. Only delays or modifications that affect critical activities or cause noncritical activities to become critical will be considered for time extensions.

When a Critical Path Method schedule is used, no time extension will be made for delays or modifications that use available float as shown in the most current approved schedule existing before the impact.

No time extension will be made for a claim that states insufficient time was provided in the contract.

(d) Execution of the Time Impact Analysis. Incorporate accepted logic changes or time extensions into the baseline schedule by the next monthly submittal.

108.04 Failure to Complete Work on Time. Follow the requirements of FAR Clause 52.211-12 Liquidated Damages — Construction.

Liquidated damages in the amount specified in Table 108-1 will be assessed for each day beyond the time allowed to complete the contract until substantial completion of the work.

If a winter shutdown occurs during this period, liquidated damages in an amount equal to 10 percent of the amount specified in Table 108-1 will be assessed for each day until work resumes at which time full liquidated damages will be assessed.

Liquidated damages in an amount equal to 20 percent of the amount specified in Table 108-1 will be assessed for each day beyond the time allowed to complete the contract beginning with the day after substantial completion and ending with the date of final completion and acceptance.

Liquidated damages will not be assessed for the following:

(a) Day of the final inspection;

(b) Days required to perform work added to the contract after substantial completion including items identified during the final inspection that were not required before that time;

(c) Delays by the Government after all work is complete and before a formal acceptance is executed; or

(d) Periods of time when all work is complete, but acceptance is delayed pending the plant establishment period or similar warranty period.

Table 108-1
Charge for Liquidated Damages for Each Day
Work Is Not Substantially Completed

Original Contract Price		Daily Charge
From More Than —	To and Including —	
$0	$1,000,000	$1,000
$1,000,000	$2,000,000	$1,800
$2,000,000	$5,000,000	$3,500
$5,000,000	$10,000,000	$4,400
$10,000,000	and more	$5,200

108.05 Stop Order. The CO may order the performance of the work to be stopped, either in whole or in part, for such periods deemed necessary due to the following:

(a) Weather or soil conditions considered unsuitable for prosecution of the work; or

(b) Failure of the Contractor to:

(1) Correct conditions unsafe for the workers or the general public;

(2) Carry out written orders given by the CO; or

(3) Perform provisions of the contract.

No adjustment in contract time or amount will be made for stop orders issued under Subsection 108.05(a) or (b), except an adjustment in contract time, as provided by FAR Clause 52.249-10 Default (Fixed-Price Construction), may be made when the Contractor is able to demonstrate that the weather was unusually severe based on the most recent 10 years of historical data.

Section 109. — MEASUREMENT AND PAYMENT

109.01 Measurement of Work. Take and record measurements and perform calculations to determine pay quantities for invoicing for work performed. Take or convert measurements of work according to U.S. Customary (Metric) measure.

Unless otherwise specified, measure when the work is in-place and complete according to the contract. Measure the actual work performed, except do not measure work outside the design limits or other adjusted or specified limits (staked limits). Measure structures to the lines according to the plans or to approved lines adjusted to fit field conditions.

Take measurements as described in Subsection 109.02 unless otherwise modified by the Measurement Subsection of the Section controlling the work being performed. Measurement of quantities for payment for the individual pay items will be based on the contract price for each pay item according to Table 109-1.

Table 109-1
Decimal Accuracy of Quantities for Payment

Contract Price	Decimal Accuracy of Quantities for Payment
< $1.00	0 decimal
≥ $1.00 to < $100.00	1 decimal
≥ $100.00 to < $1000.00	2 decimals
≥ $1000.00	3 decimals

Decimal precision for measurement is one decimal beyond accuracy of quantities for payment.

Remeasure quantities if it has been determined that a portion of the work is acceptable, but has not been completed to the lines, grades, and dimensions shown in the plans or established by the CO.

Submit measurement notes within 24 hours of completing work that is in-place and complete according to the contract. For on-going work, submit measurement notes daily. When work is not complete, identify the measurement as being an interim measurement. Submit the final measurement when the installation is completed. Measurement notes form the basis of the Government's receiving report; see Subsection 109.08(d). For lump sum pay items, submit documentation to support invoiced progress payment on a monthly basis.

Use an acceptable format for measurement records. As a minimum, include the following information:

(a) Project number and name;

(b) Pay item number and description;

(c) Date the work was performed;

(d) Location of the work;

(e) Measured quantity;

(f) Calculations made to arrive at the quantity;

(g) Supporting sketches and details as needed to clearly define the work performed and the quantity measured;

(h) Names of persons measuring the work;

(i) Identification as to whether the measurement is interim or final; and

(j) Signed certification statement by the persons taking the measurements and performing the calculations, that the measurements and calculations are correct.

109.02 Measurement Terms and Definitions. Unless otherwise specified, the following terms are defined as follows:

(a) Acre (Hectare). 43,560 square feet (10,000 square meters). Make longitudinal and transverse measurements for area computations horizontally. Do not make deductions from the area computation for individual fixtures having an area of 500 square feet (50 square meters) or less.

(b) Contract quantity. The quantity to be paid is the quantity listed in the bid schedule. The contract quantity will be adjusted for authorized changes that affect the quantity or for errors made in computing this quantity. If there is evidence that a quantity specified as a contract quantity is incorrect, submit calculations, drawings, or other evidence indicating why the quantity is in error and request in writing that the quantity be adjusted.

(c) Cubic yard (Cubic meter).

(1) Cubic yard (Cubic meter) in-place. Measure solid volumes by a method approved by the CO or by the average end area method as follows:

(a) Take cross-sections of the original ground and use design or staked templates to determine end areas. Do not measure work outside of the lines or slopes established by the CO;

(b) If a portion of the work is acceptable, but is not completed to the established lines and slopes; retake cross-sections or comparable measurements of that portion of the work. Use the remeasurements to calculate new end areas; and

(c) Compute the quantity using the average end areas multiplied by the horizontal distance along a centerline or reference line between the end areas. Deduct quantities outside the designed or staked limits.

(2) Cubic yard (Cubic meter) in the hauling vehicle. Measure the cubic yard (cubic meter) volume in the hauling vehicle using three-dimensional measurements at the point of delivery. Use vehicles bearing a legible identification mark with the body shaped so the actual contents may be readily and accurately determined. Before use, mutually agree in writing on the volume of material to be hauled by each vehicle. Vehicles carrying less than the agreed volume may be rejected or accepted at the reduced volume.

Level selected loads. If leveling reveals the vehicle was hauling less than the approved volume, reduce the quantity of all material received since the last leveled load by the same ratio as the current leveled load volume is to the agreed volume. Payment will not be made for material in excess of the agreed volume.

Material measured in the hauling vehicle may be weighed and converted to cubic yards (cubic meters) for payment purposes if the conversion factors are mutually agreed to in writing.

(3) Cubic yard (Cubic meter) in the structure. Measure according to the lines of the structure as shown in the plans, except as altered by the CO to fit field conditions. Make no deduction for the volume occupied by reinforcing steel, anchors, weep holes, piling, or pipes less than 8 inches (200 millimeters) in diameter.

(4) Cubic yard (Cubic meter) by metering. Use an approved metering system.

(d) Day. A calendar day beginning and ending at midnight. Round portions of a day up to the full day.

(e) Each. One entire unit. Measure the actual number of units completed and accepted.

(f) Gallon (Liter). The quantity may be measured by the following methods:

(1) Measured volume container.

(2) Metered volume. Use an approved metering system.

(3) Commercially-packaged volumes.

(4) Measured by mass. Use an approved weighing device.

When asphalt material is measured by the gallon (liter), measure the volume at 60 °F (15 °C) or correct the volume to 60 °F (15 °C) using recognized standard correction factors.

(g) Hour. 60 minutes. Measure the actual number of hours ordered by the CO and performed by the Contractor. Round portions of an hour up to the next half hour. Measure time in excess of 40 hours per week at the same rate as the first 40 hours.

(h) Linear foot (Meter). As applicable, measure the work along its length from end-to-end; parallel to the base or foundation; along the top; along the front face; or along the invert. Do not measure overlaps.

(i) Lump sum. Do not measure directly. The bid amount is complete payment for all work described in the contract and necessary to complete the work for that pay item. The quantity is designated as "*All*". Estimated quantities of lump sum work shown in the contract are approximate.

(j) M-gallon. 1,000 gallons. Measure according to Subsection 109.02(f).

(k) Mile (Kilometer). 5,280 linear feet (1000 meters). Measure horizontally along the centerline of each roadway, approach road, or ramp.

(l) Month. A month as defined by the Gregorian calendar. Measure portions of a month by prorating based on the total days worked.

(m) Pound (Kilogram). Measure according to Subsection 109.03. If sacked or packaged material is furnished, the net weight as packed by the manufacturer may be used.

(n) Slurry unit. Approximately 1,000 gallons (4000 liters) of water plus the specified material. Four (ten) slurry units contain material to cover one acre (hectare). Measure according to Subsection 109.02(f).

(o) Square foot and Square yard (Square meter). 1 square yard equals 9 square feet. Measurements for area computations will be made horizontally or vertically to the surface being measured. No deductions from the area computation will be made for individual fixtures having area of 9 square feet (1 square meter) or less.

(p) Thousand board feet measure, MFBM. 1000 board feet. Measurement equal to 1,000 feet of wood that is 12 inches wide and 1 inch thick.

(q) Ton (Metric ton). 2,000 pounds avoirdupois (1000 kilograms). Measure according to Subsection 109.03.

No adjustment in a contract price will be made for variations in quantity due to differences in the specific gravity or moisture content.

Use net-certified scale masses or masses based on certified volumes in the case of rail shipments as a basis of measurement subject to correction when asphalt material is lost from the car or the distributor, wasted, or otherwise not incorporated in the work. When asphalt material is shipped by truck or transport, net-certified masses, subject to correction for loss or foaming, may be used for computing quantities.

When emulsified asphalt is converted from volume to mass, use a factor of 240 gallons per ton (1000 liters per metric ton) regardless of temperature.

When asphalt binder for asphalt concrete pavement is stored in tanks devoted exclusively to the project, base quantities on invoices. When asphalt binder for asphalt concrete pavement is not stored in tanks devoted exclusively to the project or when the validity of the quantity requested for payment is in question; base quantities on the asphalt content determined by testing.

(r) Week. A 7 day period beginning and ending at the same designated time. Measure portions of a week by prorating based on the total days worked.

109.03 Weighing Procedures and Devices. Batch masses may be acceptable for determination of pay quantities when an approved automatic weighing, cycling, and monitoring system is included as part of the batching equipment.

When a weighing device is determined to indicate less than true mass; no additional payment will be made for material previously weighed and recorded. When a weighing device is determined to indicate more than true mass; material received after the last previously correct weighing accuracy test will be reduced by the percentage of error in excess of 0.5 percent.

When material is proportioned or measured and paid for by mass, provide one of the following:

(a) Commercial weighing system. Use permanently-installed and certified commercial scales.

(b) Invoices. If bulk material is shipped by truck or rail and is not passed through a mixing plant, submit a supplier's invoice with net mass or volume converted to mass. Periodic check weighing may be required.

(c) Project weighing system. Furnish, erect, and maintain acceptable automatic digital scales. Provide scales that record mass at least to the nearest 100 pounds (50 kilograms). Maintain the scale accuracy to within 0.5 percent of the correct mass throughout the range of use.

Do not use spring balances.

Install and maintain platform scales with the platform level with rigid bulkheads at each end. Make the platform of sufficient length to permit simultaneous weighing of all axle loads of the hauling vehicle. Coupled vehicles may be weighed separately or together according to Subsection 2.20, paragraph UR.3.3, *Single-Draft Vehicle Weighing* of NIST *Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*.

Install and maintain belt-conveyor scales according to Subsection 2.21, *Belt-Conveyor Scale Systems* of NIST *Handbook 44*.

Before production on the project, after relocation, and at least once per year; have the weighing portion of the system checked and certified by the State Bureau of Weights and Measures or a private scale service certified by the Bureau of Weights and Measures. Seal the system to prevent tampering or other adjustment after certification.

Attach an automatic printer to the scale that is programmed or otherwise equipped to prevent manual override of all mass information. For weighed pay quantities, program the printer to provide the following information for each weighing:

(1) Project number and name;

(2) Pay item number and description;

(3) Date;

(4) Time;

(5) Ticket number;

(6) Haul unit number;

(7) Net mass in load at least to the nearest 100 pounds (50 kilograms);

(8) Subtotal net mass for each haul unit since the beginning of the shift; and

(9) Accumulated total net mass for all haul units since the beginning of the shift.

If a printer malfunctions or breaks down, the Contractor may manually weigh and record masses for up to 48 hours provided the method of weighing meets other contract requirements.

Furnish competent scale operators to operate the system.

When platform scales are used, weigh empty haul units at least twice per day.

Use an approved format for the mass records. Submit the original records and a written certification as to the accuracy of the masses at the end of each shift.

109.04 Receiving Procedures. When the method of measurement requires weighing or volume measurement in the hauling vehicle, furnish a person to direct the spreading and distribution of material and to record the location and placement of the material on the project. During the placement, maintain a record of each delivery and document it in an acceptable manner. Include the following as applicable:

(a) Project number and name;

(b) Pay item number and description;

(c) Location where placed;

(d) Date;

(e) Load number;

(f) Truck identification;

(g) Time of arrival;

(h) Mass or volume; and

(i) Spread person's signature.

Use an approved format for the delivery records. Submit the original records and a written certification of the delivery of the material at the end of each shift.

109.05 Scope of Payment. Payment for contract work is provided, either directly or indirectly, under the pay items listed in the bid schedule.

(a) Direct payment. Payment is provided directly under a pay item listed in the bid schedule when one of the following applies:

(1) The work is measured in the Measurement Subsection of the Section ordering the work and the bid schedule contains a pay item for the work from the Section ordering the work.

(2) The Measurement Subsection of the Section ordering the work, references another Section for measuring the work and the bid schedule contains a pay item for the work from the referenced Section.

(b) Indirect payment. Work for which direct payment is not provided is a subsidiary obligation of the Contractor. Payment for such work is indirectly included under other pay items listed in the bid schedule. This includes instances when the Section ordering the work references another Section for performing the work and the work is not referenced in the Measurement Subsection of the Section ordering the work.

Compensation provided by the pay items included in the bid schedule is full payment for performing contract work in a complete and acceptable manner. Risk, loss, damage, or expense arising out of the nature or prosecution of the work is included in the compensation provided by the pay items.

Work measured and paid for under one pay item will not be paid for under other pay items.

The quantities listed in the bid schedule are approximate unless designated as a contract quantity. Limit pay quantities to the quantities staked, ordered, or otherwise authorized before performing the work. Payment will be made for the actual quantities of work performed and accepted or material furnished according to the contract. No payment will be made for work performed in excess of that staked, ordered, or otherwise authorized.

109.06 Pricing of Adjustments. Determine costs according to FAR Part 31 Contract Cost Principles and Procedures. Follow the requirements of FAR clauses providing for an equitable price adjustment.

If agreement on price and time cannot be reached, the CO may make a unilateral determination.

If the work will delay contract completion, request a contract time extension according to Subsection 108.03.

(a) Proposal.

(1) General. Submit a written proposal for each line item of the work or a lump sum for the total work. Identify the major elements of the work, the quantity of the element, and its contribution to the proposed price. Submit further breakdowns if requested by the CO.

(2) Data. Submit information as requested by the CO to the extent necessary to permit the CO to determine the reasonableness of the proposed price.

(3) Cost or pricing data. When the contract modification exceeds the amount indicated in FAR Clause 52.214-27 Price Reduction for Defective Cost or Pricing Data - Modifications - Sealed Bidding, FAR Clause 52.215-10 Price Reduction for Defective Certified Cost or Pricing Data, or FAR Clause 52.215-11 Price Reduction for Defective Cost or Pricing Data - Modifications, and the CO has determined that an exception does not apply, submit cost or pricing data.

Submit cost or pricing data, as defined in FAR Subpart 2.1—Definitions, for the Contractor and each major subcontractor.

Submit with the cost or pricing data a written proposal for pricing the work according to Subsection 109.06(a)(1). See FAR Subpart 15.4—Contract Pricing and FAR Table 15-2—*Instructions for Submitting Cost/Price Proposals when Certified Cost or Pricing Data are Required* for guidance.

Certify cost or pricing data according to FAR Subpart 15.4, upon completion of negotiations.

(b) Post-work pricing. When a contract modification is not forward priced, it requires a change order and a supplemental agreement reflecting the resulting equitable adjustment. When negotiating the price of a contract modification after all or most of the work has been performed, submit the following:

(1) Direct costs.

(a) Material. Include invoices showing the cost of material delivered to the work.

(b) Labor. Show basic hourly wage rates, fringe benefits, applicable payroll costs (that is FICA, FUTA, worker's compensation, insurance, and tax levies), paid subsistence, and travel costs for each labor classification and foreman employed in the adjusted work.

(c) Equipment. Include a complete descriptive listing of equipment including make, model, and year of manufacture. Support rented or leased equipment costs with invoices. Determine allowable ownership and operating costs for Contractor- and subcontractor-owned equipment as follows:

(1) Use actual equipment cost data when such data can be determined from the Contractor's or subcontractor's ownership and operating cost records.

(2) When actual costs cannot be determined, use the rates shown in the U.S. Army Corps of Engineers *Construction Equipment Ownership and Operating Expense Schedule (CEOOES)* for the region where costs are incurred. Adjust the rates for used equipment and for other variable parameters used in the schedules.

(3) Compute standby costs from acceptable ownership records or when actual costs cannot be determined according to *CEOOES*. Do not exceed 8 hours in a 24-hour period or 40 hours in a week. Do not include standby for periods when the equipment would have otherwise been in an idle status or for equipment that was not in operational condition.

(d) Other direct costs. Include documentation or invoices to support other direct costs incurred that are not included above (such as bonds, mobilization, demobilization, permits, and royalties).

(e) Production rates. Include actual hours of performance on a daily basis for each labor classification and for each piece of equipment. Include production rate information reflecting the actual work occurring on an approved Contractor daily record document.

(f) Subcontract costs. Include supporting data as required above.

(2) Overhead. Identify overhead rates and include supporting data, which justifies the rates. List the types of costs which are included in overhead. Identify the cost pools to which overhead is applied. Apply the overhead costs to the appropriate pool.

Limit Contractor overhead applied to subcontractor payments to 5 percent unless a higher percentage is justified.

(3) Profit. Include a reasonable profit, except when precluded by the FAR.

For work priced after all or most of the work is performed, profit is limited to 10 percent of the total cost. Due to the limited risk in post-work pricing, a lower profit percentage may be determined by a profit analysis according to FAR Subpart 15.404-4 Profit.

109.07 Eliminated Work. Follow the requirements of FAR Clause 52.243-4 Changes.

Work may be eliminated from the contract without invalidating the contract. The Contractor is entitled to compensation for direct costs incurred before the date of elimination of work plus profit and overhead on the direct incurred costs. Anticipated profit and overhead expense on the eliminated work will not be compensated.

109.08 Progress Payments. Follow the requirements of FAR Clause 52.232-5 Payments under Fixed-Price Construction Contracts and FAR Clause 52.232-27 Prompt Payment for Construction Contracts.

(a) General. Only invoice payments will be made under this contract. Invoice payments include progress payments made monthly as work is accomplished and the final payment made upon final acceptance. Only one progress payment will be made each month. No progress payment will be made in a month in which the work accomplished results in a net payment of less than $1,000. Full or partial progress payment will be withheld until a construction schedule or schedule update is approved by the CO.

(b) Closing date and invoice submittal date. The closing date for progress payments will be designated by the CO. Include work performed after the closing date in the following month's invoice. Submit invoices to the designated billing office.

(c) Invoice requirements. Submit the invoice to the Government's designated billing office with the following items in the invoice:

(1) The information required in FAR Clause 52.232-27(a)(2).

(2) A tabulation of total quantities and contract prices of work accomplished or completed on each pay item. Do not include quantities unless field note documentation for those quantities were submitted by the closing date. Do not include quantities of work involving material for which test reports required under Section 153, Section 154, or certifications required by Subsection 106.03 are, or will be, past due as of the closing date.

(3) The certification required by FAR Clause 52.232-5(c) and if applicable, the notice required by FAR Clause 52.232-5(d). Provide an original signature on the certification. Facsimiles are unacceptable.

(4) If applicable, a copy of the notices that are required by FAR Clause 52.232-27(e)(5) and (g).

(5) The amount included for work performed by each subcontractor under the contract.

(6) The total amount of each subcontract under the contract.

(7) The amounts previously paid to each subcontractor under the contract.

(8) Adjustments to the proposed total payment that relate to the quantity and quality of pay items. Adjustments for the following may be made by the Government after validation of the invoice:

(a) Retent resulting from a failure to maintain acceptable progress;

(b) Retent resulting from violations of the labor provisions;

(c) Retent pending completion of incomplete work, other "*no pay*" work, and verification of final quantities;

(d) Obligations to the Government (such as excess testing cost or the cost of corrective work) pursuant to FAR Clause 52.246-12(g); or

(e) Liquidated damages for failure to complete work on time.

(d) Government's receiving report. The Government's receiving report will be developed using the measurement notes received by the CO and determined acceptable. Within 7 days after the closing date, the CO will be available by appointment at the Government's designated billing office to advise the Contractor of quantities and contract prices appearing on the Government's receiving report.

(e) Processing progress payment requests. No payment will be made for work unless field note documentation for the work was submitted.

(1) Proper invoices. If the invoice meets the requirements of Subsection 109.08(c) and the quantities and contract prices shown on the Contractor's invoice agree with the corresponding quantities and contract prices shown on the Government's receiving report; the invoice will be paid.

(2) Defective invoices. If the invoice does not meet the requirements of Subsection 109.08(c) or if quantities or contract prices shown on the Contractor's invoice exceed the corresponding quantities and contract prices shown on the Government's receiving report; the invoice is defective and the Contractor will be notified according to FAR Clause 52.232-27(a)(2). Defective invoices will be returned to the Contractor within 7 days after receipt by the Government's designated billing office. Correct and resubmit returned invoices. If the defects are minor, the Contractor may elect, in writing, to accept the quantities and contract prices shown on the Government's receiving report for payment.

(f) Partial payments. Progress payments may include partial payment for material to be incorporated in the work according to FAR Clause 52.232-5(b)(2), provided the material meets the requirements of the contract and is delivered on, or in the vicinity of, the project site or stored in acceptable storage places.

Partial payment for material does not constitute acceptance of the material for use in completing items of work. Partial payments will not be made for living or perishable material until incorporated into the project.

Individual and cumulative partial payments for preparatory work and material will not exceed the lesser of:

(1) 80 percent of the contract price for the pay item; or

(2) 100 percent of amount supported by copies of invoices submitted.

The quantity paid will not exceed the corresponding quantity estimated in the contract. The CO may adjust partial payments as necessary to protect the Government.

(g) Retainage. Follow the requirements of FAR Clause 52.232-5 Payments under Fixed Price Construction Contracts.

(1) Satisfactory progress includes performance of all work under the contract including submittals, schedules, certifications, reports, and drawings. When satisfactory progress has not been made, the CO may retain a maximum of 10 percent of the amount the progress payment until satisfactory progress has been made.

(2) After substantial completion of the contract, the CO may retain an amount adequate for protection of the Government.

109.09 Final Payment. Follow the requirements of FAR Clause 52.232-5 Payment under Fixed-Price Construction Contracts and FAR Clause 52.232-27 Prompt Payment for Construction.

Upon final acceptance and verification of final pay records, the Government will send a SF 1034, *Public Voucher for Purchases and Services other than Personal* (final voucher) and a release of claims document. Execute both the voucher and the release of claims, and return the documents to the Government for payment. The date of approval by the Government of the final voucher for payment constitutes the date of final settlement of the contract.

If unresolved claims exist or claims are proposed, reserve the right to the claims by listing a description of each claim and the amount being claimed on the release of claims document.

Failure to execute and return the voucher and release of claims document within 90 days after receipt will constitute execution of the documents and the release of claims against the Government arising by virtue of the contract. In this event, the day after 90 days from receipt constitutes the date of final settlement of the contract.

DIVISION 150
PROJECT
REQUIREMENTS

Section 151. — MOBILIZATION

Description

151.01 This work consists of moving personnel, equipment, material, and incidentals to the project and performing work necessary before beginning work at the project site. This work also includes obtaining permits, insurance, and bonds.

Measurement

151.02 Measure the Section 151 items listed in the bid schedule according to Subsection 109.02.

Payment

151.03 The accepted quantities will be paid at the contract price per unit of measurement for the Section 151 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for mobilization by the lump sum will be paid as follows:

(a) Bond premiums will be reimbursed according to FAR Clause 52.232-5 Payments Under Fixed-Price Construction Contracts, after receipt of the evidence of payment.

(b) When 5 percent of the original contract amount is earned from pay items (not including mobilization), 50 percent of the mobilization pay item, or 5 percent of the original contract amount, whichever is less, will be paid.

(c) When 10 percent of the original contract amount is earned from pay items (not including mobilization), 100 percent of the mobilization pay item, or 10 percent of the original contract amount, whichever is less, will be paid.

(d) Any portion of the mobilization pay item in excess of 10 percent of the original contract amount will be paid after final acceptance.

Section 152. — CONSTRUCTION SURVEY AND STAKING

Description

152.01 This work consists of performing surveying, staking, calculating, and recording data for the control of work. See FAR Clause 52.236-17 Layout of Work.

Construction Requirements

152.02 Qualifications. Provide technically qualified survey crews experienced in highway construction survey and staking. Provide personnel capable of performing in a timely and accurate manner.

152.03 Submittals. Submit the following at the preconstruction conference:

Include the following when Automated Machine Guidance **(**AMG) methods are used:

(a) Technology statement. A written statement that includes:

(1) The manufacturer, model, and software version of the AMG equipment; and

(2) Certification that the final 3D data is compatible with the AMG equipment.

(b) Personnel qualifications.

(1) The name, authority, relevant experience, and qualifications of the person with overall responsibility for the AMG system.

(2) The names, authority, and relevant experience of personnel directly responsible for operating the AMG equipment.

(c) Contractor quality control plan. Comply with Section 153 and describe procedures for checking, mechanical calibration, and maintenance of both survey and construction equipment. Include the frequency and types of checks performed.

Include a price breakdown by individual tasks when construction survey and staking is paid by the lump sum for use in making progress payments and price adjustments.

152.04 General. Conform to the following:

(a) Personnel. Provide a crew supervisor on the project whenever surveying and staking is in progress.

(b) Equipment. Furnish survey instruments and supporting equipment capable of achieving the specified tolerances.

Construction equipment controlled with a Global Positioning System (GPS) and Robotic Total Station (RTS) machine guidance system may be used in the construction of subgrade, subbase, and base aggregate courses, or other construction operations when approved.

(c) Material. Furnish acceptable tools and supplies of the type and quality suitable for highway survey work. Furnish stakes and hubs of sufficient length to provide a solid set in the ground with sufficient surface area above ground for necessary legible and durable markings.

Include staking activities in the construction schedule required under Section 155. Include the dates and sequence of each staking activity.

The Government will set horizontal control points, vertical control points, and will provide data for use in establishing control for completion of each element of the work.

Data relating to horizontal and vertical alignment, theoretical slope stake catch points, and other design data will be furnished. Reformatting and additional calculations may be required for the convenient use of the Government-furnished data. Provide immediate notification of apparent errors in the initial staking or in the Government-furnished data.

Record survey and measurement field data in an approved format. Submit as-staked data and corrections made to the Government-furnished survey data. Submit survey and measurement data at least weekly. Field data and supporting documentation become the property of the Government upon completion of the work.

Discuss and coordinate the following with the CO before surveying or staking:

(1) Surveying and staking methods;

(2) Stake marking;

(3) Grade control for courses of material;

(4) Referencing;

(5) Structure control;

(6) Field staking data;

(7) Localization of the GPS systems to the Government-established control points; and

(8) Other procedures and controls necessary for the work.

Do not start work until staking or three-dimensional (3D) verification data for the affected work has been approved.

Preserve initial reference and control points. Notify the CO of missing control points or stakes at least 10 days before beginning construction. The Government will reestablish control points missing before the beginning of construction.

Acceptance of the construction staking does not relieve the Contractor of responsibility for correcting errors discovered during the work and for bearing additional costs associated with the error.

Maintain legibility of stake markings for the duration of the project or until notified in writing the stakes are no longer needed. Replace stakes if necessary to ensure markings are maintained.

Remove and dispose of flagging, paint, lath, stakes, and other staking material after the project is complete.

152.05 Survey and Staking Requirements. Perform survey, staking, recording of data, and calculations as necessary to construct the project from the initial layout to final completion. Survey and set stakes to the tolerances in Table 152-1. Reset stakes, refine 3D data, or both as many times as necessary to construct the work.

(a) Control points. Relocate initial horizontal and vertical control points in conflict with construction to areas that will not be disturbed by construction operations. Furnish the coordinates, elevations, and supporting documentation for the relocated points before the initial points are disturbed. Set durable monuments for survey control that uniquely identify the points.

Furnish the GPS localization results at least 7 days before beginning construction layout survey work. The CO may order the GPS localization calibration and associated 3D model to be broken into two or more zones to maintain the localized relationship between control points and original ground.

(b) Centerline establishment. Establish or reestablish centerline at roadway design cross-section locations and as necessary to construct the work. Reestablish the centerline when construction survey and staking work does not meet the tolerances.

(c) Original ground topographic verification. Use an approved method to regenerate cross-section data in areas where theoretical and actual ground elevations do not meet a tolerance of plus or minus 0.5 feet (150 millimeters). Retake cross-section to verify existing ground topography to mapping. Submit cross-section or 3D data in electronic and printed format for approval. Reduce cross-sections to horizontal and vertical distances from centerline.

Retake cross-section 10 feet (3 meters) beyond catch points to verify existing ground topography.

(d) Slope and references stakes. Perform the following:

(1) AMG method. After clearing operations are completed, set centerline reference stakes and hubs on both sides of centerline at 100-foot (30-meter) intervals at the clearing limit locations. Where clearing limits are greater than 10 feet (3 meters) vertically, 25 feet (8 meters) horizontally, or both from subgrade hinge point; provide an additional reference stake and hub as approved by the CO. Label each centerline reference stake with station, hub elevation, and offset from centerline.

Construct a 1000-foot (300-meter) long test section using AMG on the project at an approved location before beginning grading operations. Select a test location with superelevation and curve widening transitions if applicable. Notify the CO 10 days before beginning the test section. Demonstrate capability, knowledge, equipment, and experience to achieve work within tolerances. Allow 14 days to evaluate the test section. Do not start full grading operations until the test section is approved.

Provide as-built cross-sections at random locations specified by the CO not to exceed 500-foot (150-meter) intervals. If as-built cross-sections do not meet the tolerances in Subsection 204.13(d); rework the section until the specified tolerances are achieved and provide additional cross-sections as directed by the CO at no cost to the Government.

(2) Conventional survey methods. Verify and set slope stakes on both sides of centerline at the theoretical catch point. If the theoretical catch point is not within a tolerance of 0.5 feet (150 millimeters), perform original ground topographic verification according to Subsection 152.05(c). Set the slope stake at the actual intersection of the design roadway slope with the natural ground-line. Set reference stakes outside the clearing limits. Include reference points and slope-stake information on the reference stakes.

Establish slope stakes in the field as the actual point of intersection of the design roadway slope with the natural ground-line when theoretical catch point information is not available.

(e) Clearing and grubbing limits. Set clearing and grubbing limits on both sides of centerline based on the actual slope-stake locations.

(f) Grade-finishing stakes.

(1) AMG method. Construct a 1000-foot (300-meter) long test section using AMG on the project at an approved location before beginning grading operations. Select a test location with superelevation and curve widening transitions if applicable. Notify the CO 10 days before beginning the test section. Demonstrate the capability, knowledge, equipment, and experience to achieve work within tolerances. Allow 14 days to evaluate the test section. Do not start full grading operations until the test section is approved.

Verify the grade elevation and horizontal alignment of roadway grade-finishing operations. Use conventional survey methods at random locations specified by the CO, not to exceed 500-foot (150-meter) intervals. Submit 3D coordinates of grade-finishing quality control checks.

(2) Conventional survey methods. Set grade-finishing stakes for grade elevations and horizontal alignment, on centerline and on each shoulder at design roadway cross-section locations. Set stakes at the top of subgrade and the top of each aggregate course. Reset grade finishing stakes as many times as necessary to construct the subgrade and each aggregate course.

During turnout or pullout construction, set stakes on the centerline, on each normal shoulder, and on the shoulder of the turnout. In parking areas, set stakes at the center and along the edges of the parking area. Set stakes in ditches to be paved.

When the centerline curve radius is less than or equal to 250 feet (75 meters), use a maximum longitudinal spacing between stakes of 25 feet (8 meters). When the centerline curve radius is greater than 250 feet (75 meters), use a maximum longitudinal spacing between stakes of 50 feet (15 meters). Use a maximum transverse spacing between stakes of 20 feet (6 meters). Use brushes or guard stakes at each stake.

(g) Culverts. Verify and set culvert locations at the inlet, outlet, and inlet basin points according to the plans. Perform the following if culvert design does not fit field conditions:

(1) Survey and record the ground profile along the culvert centerline;

(2) Determine the slope catch points at the inlet and outlet;

(3) Set reference points and record information necessary to determine culvert length and end treatments;

(4) Plot to scale the profile along the culvert centerline. Show the natural ground, the flow line, the roadway section, and the culvert including end treatments and other appurtenances. Show elevations, grade, culvert length, and degree of elbow.

(a) For single skewed culverts, submit a plotted field-design cross-section normal to roadway centerline and at each end section. Plot the offset and elevation of natural ground at the end section and at proposed template break points between centerline and the end section. Ensure the template design embankment slope is not exceeded;

(b) For multiple skewed culverts, submit a plotted field design cross-section normal to roadway centerline and at the end sections (left and right) nearest to the shoulder. Plot the offset and elevation of natural ground at the end section and at proposed template break points between centerline and the end section. Ensure the template design embankment slope is not exceeded;

(c) Submit the plotted field-design cross-section for approval of final culvert length and alignment. Plot at a clear and readable scale;

(d) Set inlet, outlet, and reference stakes when the field design has been approved. Stake inlet and outlet ditches to make sure the culvert and end treatments (such as drop inlets) are functional; and

(e) Adjust slope, reference, and clearing stakes as necessary to provide for culvert inlet treatments in cut slopes. Readjust slope, reference, and clearing stakes as necessary when culvert inlets are moved from their plan locations. Review slope adjustments with the CO and obtain approval.

(h) Bridges. Set adequate horizontal and vertical control and reference points for bridge substructure and superstructure components. Establish and reference the bridge chord, bridge tangent, or control lines as specified on the bridge plans. Also establish and reference the centerline of each pier, bent, and abutment.

(i) Retaining walls and reinforced soil slopes. Survey and record profile measurements along the face of the proposed wall or reinforced soil slope at 5 feet (1.5 meters) and 10 feet (3 meters) in front of the wall or slope face. Take cross-sections every 25 feet (8 meters) along the length of the wall or reinforced soil slope and at major breaks in terrain within the limits designated by the CO. Measure and record points every 25 feet (8 meters) and at major breaks in terrain for each cross-section. Set additional references and control points to perform the work.

(j) Borrow and waste sites. Perform field work necessary for initial layout and measurement of the borrow or waste site. Establish site limits and clearing limits. Measure both original and final ground conditions and submit cross-sections as directed by the CO.

(k) Permanent monuments and markers. Perform survey and staking work necessary to establish permanent monuments and markers as described in Section 621 or reestablish monuments as described in Subsection 107.02.

(l) Miscellaneous survey and staking. Survey and stake other work (such as guardrail, curb and gutter, turf establishment, utilities, and excavation limits for structures) to the proper location and required tolerances. Propose staking increments for approval by the CO when not specified.

Table 152-1
Construction Survey and Staking Tolerances [1]

Staking Phase	Horizontal	Vertical
Control points set from existing Government control points	±0.03 feet (±10 millimeters)	±0.01 feet × $\sqrt{N}$ (±3 millimeters × $\sqrt{N}$)[2]
Mapping, topography, and cross-section points	±0.16 feet (±50 millimeters)	±0.16 feet (±50 millimeters)
Centerline points [3] including (PC), (PT), (POT),(POC), and references	±0.06 feet (±20 millimeters)	±0.06 feet (±20 millimeters)
Slope-stake and slope-stake references [4]	±0.16 feet (±50 millimeters)	±0.16 feet ±50 millimeters)
Culverts, ditches, and minor drainage structures stakes	±0.16 feet (±50 millimeters)	±0.06 feet (±20 millimeters)
Retaining walls stakes	±0.06 feet (±20 millimeters)	±0.03 feet (±10 millimeters)
Curb and gutter stakes	±0.06 feet (±20 millimeters)	±0.03 feet (±10 millimeters)
Bridge substructures stakes	±0.03 feet (±10 millimeters)[5]	±0.03 feet (±10 millimeters)
Bridge superstructures stakes	±0.03 feet (±10 millimeters)[5]	±0.03 feet (±10 millimeters)
Clearing and grubbing limit stakes	±1.00 feet (±300 millimeters)	–
Roadway subgrade finish stakes [6]	±0.16 feet (±50 millimeters)	±0.03 feet (±10 millimeters)
Roadway finish grade stakes [6]	±0.16 feet (±50 millimeters)	±0.03 feet (±10 millimeters)

(1) At statistical 95 percent confidence level. Tolerances are relative to existing Government control points.
(2) N is the number of instrument setups.
(3) Centerline points: PC - point of curve, PT - point of tangent, POT - point on tangent, POC - point on curve.
(4) Take the cross-sections normal to the centerline ±1 degree.
(5) Bridge control is established as a local network and the tolerances are relative to that network.
(6) Includes paved ditches.

152.06 Acceptance. Construction survey and staking will be evaluated under Subsections 106.02 and 106.04.

Survey notes will be evaluated under Subsection 106.02.

Measurement

152.07 Measure the Section 152 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring grade finishing, measure one time for the subgrade and one time for each aggregate course.

When measuring miscellaneous survey and staking paid by the hour; do not measure time spent in making preparations, traveling to and from the project site, performing calculations, plotting cross-sections and other data, processing computer data, and other efforts necessary to successfully accomplish construction survey and staking.

Do not measure re-establishing missing control points or stakes after construction operations have begun.

Payment

152.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 152 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for lump sum pay items will be prorated based on the progress of the work under this Section.

Section 153. — CONTRACTOR QUALITY CONTROL

Description

153.01 This work consists of planning and implementing a construction quality process to ensure work conforms to the contract. This work also includes quality control inspection and documentation, and process control sampling and testing. See FAR Clause 52.246-12 Inspection of Construction.

Construction Requirements

153.02 Qualifications. Submit the following for approval with the Quality Control Plan:

(a) Quality control manager (QCM). Provide a QCM according to (1) or (2) below. If neither is specified, conform to (1).

(1) Full-time, on-site QCM. Provide a QCM with no responsibilities for performing testing and inspection, managing the project, or performing operations other than managing quality control and the following:

(a) One year experience managing quality control on construction projects of similar type and scope, and

(b) One of the following:

(1) Two years' experience as a construction project manager or superintendent on construction projects of similar type and scope;

(2) Three years' experience as a project engineer, resident engineer, foreman, construction inspector, or equivalent on construction projects of similar type and scope; or

(3) National Institute for Certification in Engineering Technologies (NICET) Level III certification or equivalent in highway construction or highway material.

(2) Part-time, on-site QCM. Furnish a QCM who has at least 2 years' experience in highway construction, inspection, quality control, and material testing.

(b) Inspectors. Provide inspectors with at least 2 years' experience inspecting projects of similar complexity and with training related to the work to be inspected.

(c) Testers. Provide testers with at least one year experience in the type of sampling and testing required, and with one of the following for the type of sampling and testing performed:

(1) NICET Level II certification in highway material or equivalent state or industry certification;

(2) Certification by a regional certification program (such as Western Alliance for Quality Transportation Construction (WAQTC), Northeast Transportation Technician Certification Program (NETTCP), Southeast Task Force for Technician Training and Qualification (STFTTQ), or Multi Regional Training and Certification (M-TRAC)); or

(3) At least one year employment by an AASHTO accredited laboratory performing equivalent sampling and testing.

153.03 Quality Control Plan (QCP). Develop a QCP addressing all contract work categories. A category consists of related work items performed in one operation(such as excavation, drainage, and paving). Include the work of subcontractors, major material suppliers, and structural and geotechnical services suppliers.

For each category, include the following:

(a) Quality control personnel. Furnish the name, authority, responsibilities, and qualifications of the quality control manager and other personnel directly involved in inspection and testing. Conform to Subsection 153.02.

(b) Quality control procedures. Describe the inspection, testing, and other activities to be performed for each phase of work in Subsection 153.04. Include methods, schedules, equipment, and laboratory facilities. Conform to Subsections 153.04 and 153.05.

List the material to be tested by:

(1) Pay item;

(2) Applicable requirements of the Sampling, Testing, and Acceptance Requirements tables;

(3) Persons responsible for performing the sampling and testing;

(4) Laboratory testing facilities to be used for process control and project testing; and

(5) Proposed reporting formats.

As a minimum perform process control testing according to the Sampling, Testing, and Acceptance Requirements tables included at the end of each Section where applicable.

(c) Records. Describe the reporting format for inspection, testing, certification, and daily reports. Conform to Subsections 153.06 and 153.07.

At least 14 days before the start of work, submit the QCP for approval. Do not perform work on a work category unless the quality control for that category is accepted. Approval does not imply that the QCP will result in contract compliance.

Revise the QCP when contract quality requirements are not achieved and when changes occur in the contract, work progress, or personnel.

153.04 Prosecution of Work. Complete the following:

(a) Preparatory phase.

(1) Before starting each work category, hold a preparatory phase meeting. Include the project superintendent, work foreman, CO, QCM, and appropriate subcontractors. Be prepared to discuss the following:

(a) Contract requirements for the work, including acceptance procedures, schedule, and control strip;

(b) Process and equipment for constructing the work; and

(c) Plan for inspection, process control, testing, measuring, and reporting the work.

(2) Review and coordinate certifications, submittals, plans, drawings, and permits.

(3) Verify the capabilities of equipment, material, and personnel. Provide training as necessary.

(4) Establish a detailed testing schedule based on the production schedule.

(5) Ensure preparatory testing and inspection is accomplished.

(6) Review accuracy of the surveying and staking.

(b) Start-up phase.

(1) Hold a start-up meeting to review the contract, the construction processes, and the inspection, testing, and reporting requirements with the personnel performing the work. Include the project superintendent, inspectors, testers, CO, and QCM. Explain procedures that will be followed if defective work is identified.

(2) Inspect, test, and report start-up work according to the QCP and ensure the work conforms to the contract.

(c) Production phase.

(1) Inspect, test, and report according to the QCP and evaluate the acceptability of the work produced.

(2) Identify and correct deficiencies.

(3) Request Government inspection and acceptance.

153.05 Sampling and Testing. Inspect commercial laboratory equipment within 45 days of project use.

Have mobile laboratory equipment inspected and calibrated after the laboratory is moved to the project and every time it is moved thereafter. Keep laboratory facilities clean and maintain equipment in proper working condition. Certify that equipment conforms to testing requirements and submit evidence of current calibrations.

Allow the CO unrestricted access to the laboratory for inspection and review. When requested by the CO, provide additional inspections and tests to demonstrate sampling and testing proficiency. Submit proficiency sample test results within 48 hours of sample receipt.

Perform quality control sampling and testing according to the QCP and the sampling, testing, and acceptance requirements table in applicable sections.

When no sampling frequencies are specified, submit the proposed sampling and testing frequencies.

153.06 Certifications. Obtain, review, and verify certifications for work. Submit certifications when required.

153.07 Records and Control Charts. Maintain records and control charts by pay item.

(a) Quality control and construction operations reports. Submit written quality control and construction operations reports daily according to the QCP. Document meetings, work locations, labor and equipment used including actual hours worked, testing and measurement activities, inspection results, deficiencies observed, corrective actions taken, and process changes. Use FHWA Form 1413, *Inspector's Daily Record of Construction Operations* or approved alternate forms. Include the following certification signed by the QCM on all reports:

> "*I certify that the information contained in this record is accurate and that work documented herein complies with the contract. Exceptions to this certification are documented as a part of this record.*"

(b) Control charts. Maintain linear control charts that identify the test number, test parameter, upper and lower specification limit applicable to each test parameter, and test results for applicable material. Use the control charts to document variability of the process, to identify production and equipment problems, and to identify actions to improve processes or quality.

Update and post control charts daily in a location accessible to the CO. Cease production and correct the process when problems are evident.

153.08 Acceptance. The Contractor's quality control system will be evaluated under Subsection 106.02 based on its demonstrated effectiveness to ensure work conforms to the contract.

Measurement and Payment

153.09 Do not measure Contractor quality control for payment. See Subsection 109.05.

Section 154. — CONTRACTOR SAMPLING AND TESTING

Description

154.01 This work consists of obtaining samples for testing.

When there is a pay item for Contractor testing included in the bid schedule, this work also includes sampling, testing and reporting the required test results. It excludes Contractor quality control testing required under Section 153.

Construction Requirements

154.02 General. Include the work required under this Section in the Section 153 quality control plan.

Sample and test material according to the Sampling, Testing, and Acceptance Requirements tables included at the end of each Section. Perform additional sampling and testing as directed when material does not meet requirements.

Provide the CO the opportunity to witness sampling, splitting, and testing of material.

Where process control sampling and testing frequencies are identical to the sampling and testing frequencies for acceptance, the process control samples may be used for acceptance for the applicable work.

154.03 Sampling. Sample and split samples according to AASHTO or other acceptable procedures. The location of statistical acceptance sampling will be provided using a random number system. Perform splits when required and deliver the Government's portion of the sample or split sample in an acceptable container suitable for shipment. Label samples with the following:

(a) Project number and name;

(b) Pay item number and description;

(c) Source of material;

(d) Sample number;

(e) Date sampled;

(f) Time sampled;

(g) Location sample taken;

(h) Name of person sampling;

(i) Name of person witnessing sampling; and

(j) Type of test required on sample.

154.04 Testing. Perform tests when there is a pay item for Contractor testing included in the bid schedule. Demonstration of testing competence may be required.

154.05 Records. When tests are on material being incorporated in the work, report test results within 24 hours unless specified otherwise in the Sampling, Testing, and Acceptance Requirements tables. Report test results on forms containing sample information required by Subsection 154.03. Label interim measurements used to determine the results. Attach work sheets used to determine test values to the test result forms. Payment for work may be delayed or the work stopped until test results are submitted.

154.06 Acceptance. Contractor sampling and testing will be evaluated under Subsections 106.02 and 106.04 based on Government verification testing.

Measurement

154.07 Measure the Section 154 pay items listed in the bid schedule according to Subsection 109.02.

Payment

154.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 154 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for Contractor testing lump sum will be paid as follows:

(a) 25 percent of the pay item amount, not to exceed 0.5 percent of the original contract amount, will be paid after the testing facilities are in place, qualified sampling and testing personnel are identified, and the work being tested has started.

(b) Payment for the remaining portion of the pay item amount will be prorated based on the total work completed in Section 154.

Payment may be retained if Government verification testing does not validate the Contractor testing or if it is determined that documentation of sampling and testing does not meet requirements.

Section 155. — SCHEDULES FOR CONSTRUCTION CONTRACTS

Description

155.01 This work consists of scheduling and monitoring the progress of construction activities.

155.02 Definitions.

(a) Construction schedule. A progress time-scaled logic diagram, tabular schedule, written narrative, and submittal list.

(b) Preliminary construction schedule. A written narrative and a schedule diagram of contract activities for the first 60 days after the effective date issued in the Notice to Proceed. A schedule diagram consists of either a Bar Chart Method (BCM) or a Critical Path Method (CPM).

(c) Initial construction schedule. The first approved BCM or CPM construction schedule submitted after the preliminary construction schedule. Once approved the initial construction schedule becomes the first baseline construction schedule.

(d) Baseline construction schedule. The current approved initial construction schedule in which subsequent construction schedule updates are based on.

(e) Baseline construction schedule update. The normal monthly updating of the currently approved baseline schedule with no changes in the schedule logic or activities and no changes to the critical path.

(f) Baseline construction schedule revision. A significant change to the schedule logic, schedule activities or activity durations, or some other modification to the schedule of planned work. Activities performed out of sequence from the baseline schedule affecting the critical path require a revision. A baseline schedule revision may show construction being completed at a date other than the contract completion date.

Construction Requirements

155.03 General. Follow the requirements of FAR Clause 52.236-15 Schedules for Construction Contracts.

Designate an individual in the Contractor's organization who will be the authorized representative responsible for the construction schedule. Identify the representative before or at the preconstruction conference.

When preparing schedules, show completion of work within the contract time.

155.04 Preliminary Construction Schedule. Do not begin work, except mobilization, traffic control, and Section 637 work, without an approved preliminary construction schedule. No progress payments will be made until a preliminary construction schedule has been approved.

Submit a written narrative that includes:

(a) A title page stating the contract number, project number, project name, Contractor name, current contract completion date, date of submittal, submittal number and schedule name designated as preliminary construction schedule;

(b) A description of the work to be done within each activity including the type and quantity of equipment, labor, and material to be used;

(c) A description of the planned production rates by pay item units;

(d) A description of the work days per week, number of shifts per day, and number of hours per shift. Include calendars used in the schedule module;

(e) Estimated periods during which an activity is idle or partially idle. Show the beginning and end dates for reduced production or idle time;

(f) Identification of the vendor, supplier, or subcontractor to perform the activity. State assumptions made in scheduling their work;

(g) A description of site mobilization (such as dates of expected material shipments, planned dates for equipment arrivals, office setup, material laboratory arrival and setup, and anticipated portable crusher or batch plant setup);

(h) A list of drawing and sample submittals; and

(i) The fabrication and delivery of key and long-lead procurement activities.

Submit 2 copies of a preliminary construction schedule at least 7 days before the preconstruction conference. Within 7 days after the preconstruction conference, the preliminary construction schedule will be approved or rejected. If rejected, submit a revised schedule within 3 days.

The preconstruction conference will be rescheduled if the CO does not receive the schedule 7 days before the scheduled preconstruction conference date. Contract time will not be extended for failure to submit a preliminary construction schedule by the date required.

155.05 Initial and Baseline Construction Schedule. Prepare and submit a Critical Path Method (CPM) initial construction schedule unless otherwise required by the contract.

(a) Bar Chart Method (BCM). Include the contract number, project number, project name, Contractor name, current contract completion date, date of submittal, and submittal number.

(1) Progress bar chart.

(a) Use a time scale to graphically show the percentage of work scheduled for completion during the contract time;

(b) Define and relate activities to the contract pay items;

(c) Show activities in the order the work will be performed, including submittals, submittal reviews, fabrication, and delivery;

(d) Show critical (major) activities that are controlling factors in the completion of the work;

(e) Show the time needed to perform each activity and its relationship in time to other activities;

(f) Show the total expected time to complete work; and

(g) Provide enough space for each activity to permit two additional plots parallel to the original time span plot. Use one space for revision of the planned time span, and one for showing actual time span achieved.

(2) Written narrative. Submit a written narrative of the activities displayed in the progress bar chart. The following applies to the written narrative:

(a) Estimate starting and completion dates of each activity;

(b) Describe work to be done within each activity including the type and quantity of equipment, labor, and material to be used;

(c) Describe the location on the project where each activity occurs;

(d) Describe planned production rates by pay item quantities (such as quantity of excavation per day or week);

(e) Describe work days per week, holidays, number of shifts per day, and number of hours per shift;

(f) Estimate periods during which an activity is idle or partially idle. Show the beginning and end dates for reduced production or idle time;

(g) Describe expected and critical delivery dates for equipment or material that can affect completion of the project;

(h) Describe critical completion dates for maintaining the construction schedule; and

(i) Identify the vendor, supplier, or subcontractor to perform the activity. State assumptions made in the scheduling their work.

(3) Bar Chart Method updates. Review the construction schedule to verify or adjust: start and finish dates of activities underway, remaining duration of uncompleted activities, and finish dates of completed activities. Inform the CO of changes.

Submit 2 copies of an updated construction schedule with each progress estimate or every 30 days, whichever is less or within 2 days of:

(a) A delay occurs in the completion of a critical (major) activity;

(b) A delay occurs which causes a change in a critical activity;

(c) The actual prosecution of the work is different from that represented on the current construction schedule;

(d) There is an addition, deletion, or revision of activities caused by a contract modification; or

(e) There is a change in the schedule logic.

(b) Critical Path Method (CPM). Prepare an initial construction schedule using a CPM that is computer-generated. Submit an initial construction schedule that includes all activities, contractual requirements (such as construction or traffic staging), contract restrictions, and subcontract work.

(1) Format. Prepare a construction schedule diagram and supporting documents as follows:

(a) A title page or header block for each component (time-scaled logic diagram, tabular schedule, written narrative, and submittal list) with the contract number, project number, project name, Contractor name, current fixed completion date, date of submittal, and submittal number.

(b) A schedule diagram using the activity-on-arrow diagram method (ADM) or the precedence diagram method (PDM). Depict the order and interdependence of all activities and the sequence of the work that will be accomplished by the Contractor in coordination with its subcontractors. Show how the completion of predecessor activities restricts the start of successor activities.

(2) Time-scaled logic diagram.

(a) Show all activities including those in the preliminary construction schedule. Add items for correcting punch-list items, and general cleanup. Relate an activity or groups of activities to the contract pay items;

(b) Show all activity nodes or boxes, activity IDs, activity descriptions, and durations;

(c) Group the activities independently by area (that is separate distinct bridges or roadways) and by type of work (such as submittals, utilities, roadway, and bridge);

(d) Include a description of the work represented by each activity at or near the event node or box for each activity;

(e) Code each subcontractor’s activities so that its activities can be shown separately as well as cumulatively;

(f) Show durations for construction activities as whole working days, with a maximum duration of 30 working days each. Divide activities with longer durations into subgroups of activities not exceeding 30 working days in duration. Indicate logical start and end points (such as stationing and staging) for each subgroup;

(g) Show the durations of non-construction activities. Non-construction activities include mobilization, drawing and sample submittals by pay item number, and the fabrication and delivery of key material. Non-construction activities may have durations exceeding 30 working days consistent with the contract. Indicate intended submittal dates and delivery dates for fabrication and delivery activities. Allow for review, approval, and distribution of each submittal or resubmittal. Where no times are specified, allow 14 days for the review, approval, and distribution of each submittal or resubmittal after receipt by the CO;

(h) Indicate the total number of anticipated working days to complete each activity of work;

(i) Identify the critical path on the diagram; and

(j) Begin the construction schedule diagram with the date of the Notice to Proceed and include the contract completion date. Float time within the construction schedule is not for use or benefit of either party, but is a jointly owned project resource available to both parties as needed to meet the completion date established in the contract.

(3) Tabular schedule. Submit a tabular schedule sorted by early start and total float. Include the following information in the tabular schedule:

(a) Activity ID;

(b) Activity description;

(c) Subcontractors codes;

(d) Activity percent complete;

(e) Original and remaining duration;

(f) Early and late schedule dates;

(g) Total float;

(h) A predecessor/successor report; and

(i) Other tabular schedule report formats if requested by the CO for analyzing CPM revisions or time impacts.

(4) Written narrative. Submit a written narrative describing the rationale and assumptions utilized in the development of the construction schedule. Use the time-scaled logic diagram as the basis of schedule-related comments, referencing specific activities by number and description. Include the following:

(a) Describe the planned critical path and the general sequence of work;

(b) Information and references to adequately define the scope of work by pay item included in each major activity type (such as roadway excavation and aggregate base course). Include such information as station numbers, location, etc.;

(c) Describe the resource loading planned for use in the performance of the work for each major activity. The description should include manpower allocation by types of labor and crew size, types and number of equipment and special equipment, material, and subcontractors involved;

(d) Describe the basis (including the resource loading above) for the calculation of the duration for all major activities, to be stated as quantity production rates (such as quantity of excavation per day);

(e) Describe work days per week, number of shifts per day, and number of hours per shift;

(f) A description of the assumptions used in converting working days to calendar dates. Include anticipated holidays, non-work days, winter shutdowns, and other constraints within the contract;

(g) Identify the subcontractor or supplier performing an activity and identify their activity codes used on the schedule diagram. State assumptions made in the scheduling of the subcontractor's or supplier's work;

(h) Describe expected and critical delivery dates for equipment or material that can affect completion of the project;

(i) A description of organizational limitations (such as resource constraints or subcontractor commitments) which limit scheduling flexibility;

(j) Ensure that there is no conflict between the diagram and the narrative;

(k) An explanation of the schedule's Work Breakdown Structure (WBS), and Activity ID protocol to be use throughout the life of the work; and

(l) A list and description of constraints used in the CPM scheduling software.

(5) Submittal list.

(a) Submit a list of drawings and other submittals by pay item number required for the entire contract period.

(b) Include the following information for each submittal:

(1) Pay item number and description;

(2) Related activity ID number and description from the CPM;

(3) Planned date of initial submittal;

(4) Planned date of CO's initial response; and

(5) Other comments.

(f) Submission and approval Submit 2 paper copies and one electronic copy of the initial construction schedule within 45 days after the effective date of the Notice to Proceed has been issued. Submit an electronic copy via media approved by the CO. In case of discrepancy between the paper version and the electronic version, the paper version will govern over the electronic version of the schedule.

Allow 14 days for the approval or rejection of the schedule. If rejected, submit corrected schedule within 7 days after the date of the rejection of the schedule. If rejected, schedule a meeting within 3 days to discuss corrections.

The approved copy of the initial construction schedule with supporting documents becomes baseline construction schedule. Implement and execute the work under the contract according to the baseline construction schedule. Update the baseline construction schedule according to Subsection 155.06.

Failure to include elements of work in the construction schedule diagram that are required for performance of the contract, even when approved by the Government, will not excuse the Contractor from completing the work required by the contract completion date.

155.06 Baseline Schedule Update. Submit a baseline construction schedule update no less than 7 days before the closing date for the progress estimate or every 30 days, whichever is less. Show completion of work within the contract time. No progress payment will be made for any work until an updated construction schedule is approved by the CO.

Unless previously approval by the CO, changes to the construction schedule for work that is still to be completed, can only be changed with a Time Impact Analysis according to Subsection 108.03, and a Baseline Construction Schedule revision according to Subsection 155.08. Receipt of a baseline construction schedule update with negative float does not constitute agreement by the Government of the revised completion date.

(a) Written narrative. Submit an update of the initial or previous written narrative identifying adjustments made to each operation since the last update. Adjustments include, but are not limited to the following:

(1) Equipment added or removed from the project;

(2) Changes to labor (such as added crews or subcontractors);

(3) Work shift adjustments (such as extended hour or added shifts);

(4) Periods of anticipated suspension or holiday;

(5) Changes in material delivery;

(6) Early completion of individual work items; and

(7) Efficiency of operations

(b) Submittal list.

(1) Actual dates of initial (and expected dates for all subsequent) submittals;

(2) Actual dates of CO's initial (and expected dates for subsequent) responses;

(3) Status of CO's responses (that is approved, rejected, or approved as noted); and

(4) Comments.

(c) Bar Chart Method updates. Submit 2 paper copies of an updated baseline construction schedule. Verify or adjust: start and finish dates of activities underway, remaining duration of uncompleted activities, and finish dates of completed activities. Include the initial time span plot adjacent to the updated span plot for each work activity.

(d) Critical Path Method updates. Submit 2 paper copies and one electronic copy of the construction schedule update. Provide an electronic copy via media approved by the CO. In case of discrepancy between the paper version and the electronic version, the paper version will govern over the electronic version of the schedule.

(1) Tabular schedule:

(a) Actual finish dates for completed activities;

(b) Remaining duration required to complete each activity started, or scheduled to start, but not completed;

(c) Float remaining for each activity;

(d) Percentages for completed and partially completed activities; and

(e) Additional tabular schedules using different sort parameters when requested by the CO.

(2) Updated time-scaled logic diagram.

(e) Review and approval of a construction schedule update. The CO will review and approve the baseline construction schedule update within 7 days or return it for corrections. The approved baseline construction schedule revision will become the new baseline construction schedule.

155.07 Baseline Schedule Revision. Submit a time impact analysis when requesting approval of a baseline schedule revision. Submitting a proposed baseline schedule revision is not considered a notification of delay or of other basis for change. Continue to submit monthly schedule updates according to Subsection 155.08 until a baseline construction schedule revision is approved.

(a) Time impact analysis. Perform a time impact analysis according to Subsection 108.03 within 20 days of impacts caused by:

(1) Changes in the resource loading, durations, specifications, subcontractors;

(2) Addition or deletion of work;

(3) Increased or decreased quantities;

(4) Defective work;

(5) Acceleration of the work; or

(6) Other changes.

(b) Bar Chart Method revisions. Submit a bar chart according to Subsection 155.05(a) which includes revised construction activities affected by impacts addressed with a time impact analysis. Include a revised completion date for the total work.

(c) Critical Path Method revisions. Submit a tabular schedule and time-scaled logic diagram according to Subsection 155.05(b) which includes revised construction activities affected by impacts addressed with a time impact analysis. Include a revised critical path and completion date for the total work.

(d)Written narrative. Submit a written narrative according to Subsection 155.05 describing the changes to the critical path and logic revisions. Identify delays and disruptions which are ongoing as of the date of the proposed revision. When delays or disruptions have occurred which are the responsibility of the Contractor; propose efforts to return the project to a schedule consistent with the terms of the contract including the commitment of additional resources or other appropriate action. Notify the CO which completion dates or other terms of the contract will not be met.

155.08 Acceptance. Construction schedules and supporting documents will be evaluated under Subsection 106.02 and Subsection 109.08(a).

Measurement

155.09 Measure the Section 155 pay items listed in the bid schedule according to Subsection 109.02.

Payment

155.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 155 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for construction schedule lump sum will be paid as follows:

(a) 25 percent of the pay item amount, not to exceed 0.5 percent of the original contract amount, will be paid after the initial baseline construction schedule is approved.

(b) Payment of the remaining portion of the lump sum pay item will be prorated based on the total work completed.

Section 156. — PUBLIC TRAFFIC

Description

156.01 This work consists of controlling and protecting public traffic adjacent to and within the project. See FAR Clause 52.236-13 Accident Prevention.

Material

156.02 Conform to the following Section:

Temporary traffic control	635

Construction Requirements

156.03 Qualifications. Provide a traffic control supervisor certified by a state department of transportation, ATSSA, or other acceptable certification programs.

156.04 Accommodating Traffic During Work. Accommodate traffic according to the MUTCD, contract traffic control plan, Section 635, and this Section. An alternate traffic control plan may be submitted for approval according to Subsection 104.03. Submit alternate traffic control plans at least 30 days before intended use.

Perform work in a manner that ensures the safety and convenience of the public and protects the residents and property adjacent to the project. Accommodate public traffic on roads adjacent to and within the project until the project is accepted according to Subsection 106.07(b).

156.05 Maintaining Roadways During Work. Maintain roadways as follows:

(a) Construct and remove diversion roads and bridges as required by the traffic control plan;

(b) Maintain intersections with trails, roads, streets, businesses, parking lots, residences, garages, farms, and other features;

(c) Snow removal to facilitate the work is the Contractor's responsibility. Snow removal to provide public access is the responsibility of the maintaining agency and will be performed at the maintaining agency's discretion. Allow the maintaining agency access to perform snow removal;

(d) Maintain a dust-free traveled way such that visibility and air quality are not affected and a hazardous condition is not created;

(e) Remove accumulations of soil and other material from traveled way;

(f) Do not allow water to pond on the traveled way; and

(g) Maintain the roadway, detours, and diversions in a safe and acceptable condition.

If corrective action is requested and the corrective action is not taken immediately, the condition may be corrected and the cost of the corrective action deducted from monies due the Contractor.

156.06 Maintaining Roadways During Non-Work Periods. Maintain roadways and traffic control for public traffic during periods when work is not in progress. Snow removal to provide public access is the responsibility of the maintaining agency.

156.07 Limitations on Construction Operations. When the roadway is open to public traffic, restrict operations as follows:

(a) Operate equipment in the direction of traffic, where practical;

(b) For shoulder drop-offs of 3 inches (75 millimeters) or less, provide "*Low Shoulder*" warning signs. For shoulder drop-offs in excess of 3 inches (75 millimeters), provide a 1V:3H fillet with "*Shoulder Drop-Off*" warning signs. Complete the construction of shoulders adjacent to traffic lanes to the same elevation within 14 days;

(c) Provide minimum lane widths of 10 feet (3 meters). Use barricades, drums, or other acceptable devices to delineate traffic lanes through areas where the edge of pavement or intended path has been obliterated by construction operations;

(d) Locate staging areas at least 30 feet (9 meters) from the traveled way or behind acceptable traffic barriers. Obtain approval of the location and access to staging areas. Store unused traffic control devices at staging areas;

(e) Park equipment at least 30 feet (9 meters) from the traveled way or behind acceptable traffic barriers;

(f) Provide parking areas for employee’s personal vehicles in approved areas;

(g) Provide uninterrupted two-way communications between flaggers and also between flaggers and pilot cars unless flaggers are able to see each other and communicate. Use communications devices approved by the CO. Citizen band radios are unacceptable. Make communication devices available to the CO as necessary;

(h) Where switching traffic to a completed lane, provide adequate personnel and equipment to set or relocate traffic control devices;

(i) Limit construction-caused delays to public traffic to a maximum of 30 minutes per passage through the project; and

(j) Maintain existing guardrails, barriers, and bridge railings until removal is necessary for construction. Use a temporary barrier or appropriate channelizing devices while the guardrails and bridge rails are absent. Install permanent barriers, guardrails, and bridge rails as soon as possible to minimize risk to the public.

156.08 Nighttime Operations. Perform construction operations during the hours of daylight (one-half hour after sunrise to one-half hour before sunset).

Where night operations are permitted, submit a night lighting system for approval. Include the light types, locations, and the manner in which the lights will be moved. Submit the proposed system at least 14 days before use. Use an independent source other than vehicle headlights. Do not use incandescent lights. Furnish and install the approved system to illuminate the entire work area. Position the lights so they do not shine directly at motorists traveling from any direction. If the operation is moving, move the lighting with the operation. Provide lighting at each flagger location. Equip vehicles with an exterior flashing yellow dome light.

156.09 Traffic Control Supervisor. Provide a traffic control supervisor according to Subsection 156.03. Do not designate the superintendent as the traffic control supervisor. Furnish the traffic control supervisor's name, address, and 24-hour telephone numbers at the preconstruction conference. During the contract, including periods of suspensions and work stoppages, perform the following:

(a) Implement the traffic control plan.

(b) Coordinate traffic control operations, including those of subcontractors and suppliers.

(c) Ensure the condition, position, and applicability of traffic control devices in use.

(d) Immediately correct traffic control deficiencies.

(e) Coordinate traffic control maintenance operations with the CO.

(f) Coordinate and ensure that traffic control devices are furnished, installed, maintained, removed, stored, replaced, relocated and cleaned according to Subsection 635.04. Ensure unused traffic control devices are properly handled and stored.

(g) Conduct weekly traffic safety meetings for construction workers, and invite the CO to these weekly meetings.

(h) Submit a weekly certification that inspections and reviews were conducted and that the traffic control devices meet contract requirements. Include the number and types of devices in use. Report with the weekly certification, changes or corrective actions taken to ensure the safe passage of public traffic through the project.

(i) Inspect traffic control devices, including those in staging, storage, material sources, and disposal areas, as follows:

(1) Daily during daylight hours when daylight work is being performed;

(2) Daily during hours of darkness when nighttime work is being performed;

(3) Weekly during:

(a) Daylight hours and hours of darkness when work is suspended for periods of more than one week, except when the project has been shut down for the winter; and

(b) Periods of winter suspension, inspect only as requested by the CO.

(4) Additional inspections, day or night, as directed by the CO; and

(5) Submit reports of inspections in an acceptable format within 2 days.

(j) Before winter suspension, conduct an inspection of the project with the CO to ensure proper provisions are made for winter travel during the period of suspension.

(k) Provide temporary flagging assistance.

156.10 Acceptance. Public traffic work will be evaluated under Subsection 106.02.

Traffic control devices and services will be evaluated under Section 635.

Measurement and Payment

156.11 Do not measure controlling and protecting public traffic for payment. See Subsection 109.05.

Measure temporary traffic control under Section 635.

Measure dust abatement under Section 158 or 312.

Section 157. — SOIL EROSION AND SEDIMENT CONTROL

Description

157.01 This work consists of furnishing, constructing, and maintaining soil erosion and sediment control devices to eliminate or minimize pollutants in stormwater discharges from the project.

Material

157.02 Conform to the following Subsections:

Backfill material	704.03
Concrete masonry unit	725.07(c)
Fertilizer	713.03
Fiber rolls and socks	713.12
Floating turbidity curtains	713.21
Gravel bags	713.13
Mulch	713.05
Plastic lining	725.12
Prefabricated filter insert	713.20
Riprap	705.02
Rock mulch	705.07
Sandbags	713.14
Sediment filter bags	713.19
Seed	713.04
Separation and stabilization geotextile and geotextile filter	714.01(a)
Silt fence	713.16
Tackifiers	713.11(a)
Temporary culvert pipe	713.15
Temporary plastic fence	710.11
Temporary rolled erosion control products	713.17
Turf reinforcement mats	713.18
Water	725.01(b)

Construction Requirements

157.03 Qualifications. Submit the following for approval at least 14 days before earth disturbing operations begin:

(a) Names of personnel responsible for soil erosion and sediment control; and

(b) A résumé for each individual describing their knowledge and experience providing erosion and sediment control and pollution prevention on highway or road construction projects for at least 5 years. Include certifications in those states where applicable.

157.04 General. Provide soil erosion and sediment control measures according to the contract erosion and sediment control plan, contract permits, Section 107, and this Section. Contract permits amend the requirements of this Section. Do not modify the type, size, or location of controls or practices without approval.

The erosion and sediment control plan reflects special concerns and measures to protect resources. An alternate erosion and sediment control or stormwater pollution prevention plan, with necessary permits, may be submitted for approval according to Subsection 104.03. Submit alternate erosion and sediment control proposals at least 30 days before their intended use.

When soil erosion and sediment control measures are not functioning as intended, take corrective action to eliminate or minimize pollutants in stormwater discharges from the project.

If wood chips are used, do not import without approval from the CO.

157.05 Controls and Limitations on Work. Before grubbing or grading construct sediment controls around the perimeter of the project including filter barriers, diversion, and settling structures.

Limit the combined grubbing and grading operations areas to 8 acres (3.2 hectares) of exposed soil at one time.

Construct and implement soil erosion and sediment control measures as follows:

(a) Construct temporary controls in incremental stages as construction proceeds;

(b) Construct temporary slope drains, diversion channels, and earth berms to protect disturbed areas and slopes;

(c) When a soil disturbing activity within a portion of the project is complete, apply permanent measures to the finished slopes and ditches within 14 days;

(d) When a soil disturbing activity within a portion of the project has temporarily ceased, apply temporary measures within 14 days;

(e) Construct outlet protection as soon as culverts or other structures are complete;

(f) Construct and maintain soil erosion and sediment controls on and around soil stockpiles;

(g) Following each day’s grading operations, shape earthwork to minimize and control erosion from stormwater runoff; and

(h) Maintain stabilized construction exits to minimize tracking of soil onto existing roads.

157.06 Filter Barriers. Construct silt fence, berms, and fiber rolls and socks to reduce the velocity of runoff to allow sediment to settle.

157.07 Sediment Retention Structures. Construct sediment retention structures of the following types:

(a) Temporary sediment traps. Construct temporary sediment traps to detain runoff from disturbed areas and settle out sediment. Provide outlet protection.

(b) Sediment basins. Construct sediment basins to store runoff and settle out sediment for large drainage areas. Excavate and construct sediment basins according to Section 204. Construct riser pipes according to Section 602. Provide outlet protection.

157.08 Outlet Protection. Construct riprap aprons or basins to reduce water velocity and prevent scour at the outlet of permanent and temporary erosion and sediment control measures. Construct riprap according to Section 251.

157.09 Water Crossings. Construct temporary culvert pipe at temporary crossings where construction vehicles cross a live waterway.

157.10 Diversions. Construct temporary channels, temporary culverts, earth berms, or sandbags to divert water around disturbed areas and slopes. Use temporary channels, temporary culverts, pumps, sandbags, or other methods to divert the flow of live streams for permanent culvert installations and other work. Stabilize channels according to Subsection 157.11. Provide outlet protection.

157.11 Waterway and Slope Protection and Stabilization. Use the following:

(a) Plastic lining. Use plastic lining to protect underlying soil from erosion. Place the plastic lining loosely on a smooth soil surface free of projections or depressions that may cause the liner to puncture or tear. Lap transverse joints at least 3 feet (1 meter) in the direction of flow. Do not use longitudinal joints. Anchor the lining in place using riprap, gravel bags, or sandbags.

(b) Riprap. Construct riprap for channel lining according to Section 251.

(c) Check dams. Construct riprap, gravel bags, sandbags, fiber rolls and socks, or earth berms for temporary check dams to reduce the velocity of runoff in ditches and swales.

(d) Rolled erosion control products. Use rolled erosion control products to stabilize waterways and slopes before or after temporary or permanent seeding. Install according to Section 629.

(e) Temporary slope drains. Use drainpipe, riprap, or plastic lined waterway for temporary slope drains to channel runoff down slopes. Channel water into the slope drain with an earth berm, gravel bag, or sandbag headwall constructed at the top of a cut or fill. Anchor slope drains to the slope. Provide outlet protection.

(f) Floating turbidity curtains. Install floating turbidity curtains within a body of water to minimize the migration of silt laden water out of the construction area.

157.12 Temporary Soil Stabilization. Control soil erosion on unprotected slopes. Use the following:

(a) Temporary cover. Use mulch, plastic, rolled erosion control product, or tackifier. Apply according to the manufacturer’s recommendations or as approved by the CO.

(b) Temporary turf establishment. Apply seed and mulch for soil erosion protection at the rates shown in Table 157-1. Protect and care for seeded areas, including watering, until permanent turf establishment is in place.

Table 157-1
Application Rates for Temporary Turf Establishment

Material	Application Rate pounds/acre (kilograms/hectares)
Seed	45 (50)
Wood fiber or grass straw cellulose fiber mulch	1500 (1700)[(1)]

(1) Mulch applied using hydraulic method according to Subsection 625.08(b). For other mulch products and application methods, use the manufacturer's rate as approved by the CO.

157.13 Permanent Soil Stabilization. Control erosion on completed permanent slopes. Use the following:

(a) Turf establishment. Apply seed, fertilizer, and mulch according to Section 625.

(b) Plants, trees, shrubs, vines, groundcovers, and other plants. Furnish and plant trees, shrubs, vines, groundcovers, and other plants according to Section 626.

(c) Sod. Furnish and place sod of perennial turf-forming grasses according to Section 627.

(d) Rock mulch. Furnish and place rock on finished surfaces.

157.14 Inspection and Reporting. Inspect erosion and sediment control measures using approved personnel. When there are no contract permits, conduct erosion and sediment control inspections at least once every 7 days.

Within 24 hours after each inspection, submit an inspection report to the CO. Include the following:

(a) Date and time of the inspection;

(b) Names and titles of persons making the inspection;

(c) Summary of the inspection;

(d) Weather since the last inspection or since the start of work, if the first inspection. For each storm event, include the beginning date and time, duration, rainfall quantity in inches (millimeters), and whether discharge occurred;

(e) Weather and description of discharges occurring during the inspection;

(f) Locations of discharges or other pollutants from the site;

(g) Locations of erosion and sediment control measures that need maintenance;

(h) Locations of erosion and sediment control measures that failed to operate as designated or proved inadequate for a particular location;

(i) Locations where additional erosion and sediment control measures are needed; and

(j) Other necessary corrective actions including action taken, locations, dates, and times.

157.15 Maintenance and Cleanup. Maintain temporary erosion and sediment control measures in working condition until the project is complete or the measures are no longer needed. Remove sediment trapped in perimeter protection control measures before deposits reach 50 percent of the above ground height. Remove sediment from sediment retention structures when their capacity is reduced to 50 percent of design capacity. Use removed sediment in the work if acceptable or dispose of it according to Subsection 204.14.

Replace erosion and sediment control measures that cannot be maintained and those that are damaged by construction operations.

Remove and dispose of temporary erosion and sediment control measures when vegetation is satisfactorily established and drainage ditches and channels are lined and stabilized. Remove and dispose of erosion and sediment control measures according to Subsection 203.05.

Restore the ground to its natural or intended condition and provide permanent erosion control measures.

157.16 Acceptance. Material for erosion and sediment control measures will be evaluated under Subsections 106.02 and 106.03.

Construction, maintenance, and removal of erosion and sediment control measures will be evaluated under Subsections 106.02 and 106.04.

Separation and stabilization geotextile and geotextile filter will be evaluated under Section 207.

Measurement

157.17 Measure the Section 157 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure temporary soil stabilization on the ground surface. When measurement is by the pound (kilogram), weigh the seed in pounds (kilograms).

Measure excavation for diversion channels and sediment basins under Section 204.

Measure riprap under Section 251.

Measure permanent paved waterways under Section 608.

Measure permanent turf establishment under Section 625.

Measure plants, trees, shrubs, vines, groundcovers, and other plants under Section 626.

Measure sod under Section 627.

Measure rolled erosion control products under Section 629.

Do not measure replacement items.

Payment

157.18 The accepted quantities will be paid at the contract price per unit of measurement for the Section 157 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for erosion control measures or devices will be paid as follows:

(a) 25 percent of the pay item amount will be paid upon installation.

(b) An additional 50 percent of the pay item amount will be prorated based on total work complete.

(c) The remaining portion of the pay item amount will be paid when the temporary erosion control measure is removed from the project or at final acceptance.

Section 158. — WATERING FOR DUST CONTROL

Description

158.01 This work consists of furnishing and applying water for the control of dust caused by the work and public travel.

Material

158.02 Conform to the following Subsection:

Water	725.01(c)

Construction Requirements

158.03 General. Provide an adequate water supply and apply water uniformly across the traveled way as necessary to control dust. Uniformly apply water using pressure-type distributors, pipelines equipped with spray systems, or hoses with nozzles.

(a) Project dust control for public benefit. Control dust within the construction limits as necessary including nights, weekends, and periods of non-work when the project is open to public traffic. When the project is not open to public traffic, control dust in areas of the project that have adjacent residences or businesses. Control dust on approved, active detours established for the project. Apply water at the locations, rates, and frequencies as ordered.

(b) Other dust control. Control dust on active haul roads, in pits and staging areas, and on the project during periods not covered in Subsection 158.03(a).

158.04 Acceptance. Water will be evaluated under Subsection 106.02.

Furnishing and applying water will be evaluated under Subsection 106.02.

Measurement

158.05 Measure the Section 158 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring water for dust control by volume or mass; measure in the hauling vehicle, or by metering.

Do not measure water for dust control applied according to Subsection 158.03(b).

Payment

158.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 158 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 200
EARTHWORK

Section 201. — CLEARING AND GRUBBING

Description

201.01 This work consists of clearing and grubbing within the clearing limits designated in the plans.

Material

201.02 Conform to the following Subsections:

Backfill material	704.03
Tree wound dressing	713.08(g)

Construction Requirements

201.03 General. Construct erosion control measures according to Section 157. Perform work within designated limits.

Do not damage vegetation designated to remain. If damage occurs, repair or replace the vegetation in an acceptable manner. Where possible, preserve vegetation adjacent to bodies of water. Treat cuts or scarred surfaces of trees and shrubs with tree wound dressing.

201.04 Clearing. Within the clearing limits clear trees, brush, downed timber, and other vegetation as follows:

(a) Cut trees so they fall within the clearing limits;

(b) In areas of cut slope rounding, cut stumps flush with or below the final ground-line;

(c) In areas outside the excavation, embankment, and slope rounding limits, cut stumps to within 6 inches (150 millimeters) of the ground; and

(d) Trim tree branches that extend over the road surface and shoulders to attain a clear height of 20 feet (6 meters). If required, remove other branches to present a balanced appearance. Trim according to accepted tree surgery practices. Treat wounds with tree wound dressing.

201.05 Grubbing. Grub deep enough to remove stumps, roots, buried logs, moss, turf, or other vegetative debris as follows:

(a) Grub areas to be excavated, except for cut slope rounding areas;

(b) Grub embankment areas. Undisturbed stumps less than 24 inches (600 millimeters) in diameter may be left in place if they protrude less than 6 inches (150 millimeters) above the original ground and will be covered with more than 48 inches (1200 millimeters) of embankment. Remove all other stumps;

(c) Grub pits, channel changes, and ditches only to the depth necessary for the excavation; and

(d) Backfill stump holes and other grubbing holes with backfill material to the level of the surrounding ground according to Subsection 209.09. Compact backfill according to Subsection 209.10.

201.06 Disposal. Merchantable timber is the Contractor's property. Dispose of clearing and grubbing debris according to Subsection 203.05.

201.07 Acceptance. Clearing and grubbing will be evaluated under Subsection 106.02.

Material for tree wound dressing will be evaluated under Subsection 106.03.

Backfilling and compacting of stumps and grubbing holes will be evaluated under Section 209.

Measurement

201.08 Measure the Section 201 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not make deductions from the area computation unless excluded areas are shown in the plans.

Do not measure clearing and grubbing of borrow or material sources.

Payment

201.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 201 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 202. — ADDITIONAL CLEARING AND GRUBBING

Description

202.01 This work consists of clearing and grubbing outside the clearing limits specified in Section 201. This work also includes scalloping clearing lines, clearing vistas, thinning vegetation, special clearing and grubbing, and the removal of individual trees and stumps.

202.02 Definitions.

(a) Selective clearing. Clearing where some trees and vegetation is designated to remain.

(b) Selective clearing and grubbing. Clearing and grubbing where some trees and vegetation is designated to remain.

(c) Special clearing and grubbing. Clearing and grubbing where all trees and vegetation are removed.

(d) Removal of individual trees or stumps. Removing individual trees or stumps outside the clearing limits designated in Section 201 or outside areas designated in Subsection 202.02 (a) through (c).

Construction Requirements

202.03 General. Clear and grub according to Section 201, except as modified herein. Do not push, pull, or fall trees into trees designated to remain. Remove designated debris by methods that prevent damage to vegetation not designated to be removed. Dispose of clearing and grubbing debris according to Subsection 203.05.

202.04 Selective Clearing. Clear and dispose of trees, snags, brush, downed timber, and other vegetation designated to be removed.

202.05 Selective Clearing and Grubbing. Clear, grub, and dispose of trees, snags, brush, downed timber, stumps, roots, buried logs, moss, turf, grass, and other vegetation designated to be removed.

202.06 Special Clearing and Grubbing. Clear, grub, and dispose of trees, snags, brush, downed timber, stumps, roots, buried logs, moss, turf, grass, and other vegetation.

202.07 Removal of Individual Trees or Stumps. Remove and dispose of designated trees or stumps. Cut trees to within 6 inches (150 millimeters) of the ground.

202.08 Acceptance. Additional clearing and grubbing work will be evaluated under Subsection 106.02.

Measurement

202.09 Measure the Section 202 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring removal of individual trees by the square foot (square meter), measure the average diameter at the cutoff.

Do not measure trees less than 6 inches (150 millimeters) in diameter at the cutoff.

Payment

202.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 202 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 203. — REMOVAL OF STRUCTURES AND OBSTRUCTIONS

Description

203.01 This work consists of salvaging, removing, and disposing of buildings, fences, structures, pavements, culverts, utilities, curbs, sidewalks, and other obstructions.

Material

203.02 Conform to the following Section and Subsection:

Backfill material	704.03
Minor concrete	601

Construction Requirements

203.03 Salvaging Material. Salvage with reasonable care material designated to be salvaged. Salvage in readily transportable sections or pieces. Replace or repair members, pins, nuts, plates, and related hardware damaged, lost, or destroyed during the salvage operation. Securely attach parts to adjacent members or pack them in sturdy boxes with the contents clearly marked.

Match mark members of salvaged structures. Submit one set of drawings according to Section 104 identifying the members and their respective match marks.

Stockpile salvaged material at a designated area on the project.

203.04 Removing Material.

(a) Submittals. Submit a bridge removal plan at least 30 days before beginning bridge removal for approval. Include the following:

(1) Methods and equipment to be used;

(2) Measures to be used for protecting the environment, public, adjacent property, and workers; and

(3) Methods to keep debris out of the stream and streambed.

(b) General. Saw cut sidewalks, curbs, pavements, and structures when partial removal is required.

Construct structurally adequate debris shields to contain debris within the construction limits. Do not allow debris to enter waterways, travel lanes open to public traffic, or areas designated not to be disturbed.

Handle material with lead paint contamination according to Subsection 563.05.

Raze and remove buildings, foundations, pavements, culverts, sidewalks, curbs, fences, structures, and other obstructions interfering with the work and not designated to remain.

Remove structures and obstructions in the roadbed to 36 inches (900 millimeters) below subgrade elevation. Remove structures and obstructions outside the roadbed to 24 inches (600 millimeters) below finished ground or to the natural stream bottom.

Abandon existing manholes, inlets, catch basins, and spring boxes according to Subsection 604.08.

When abandoning an existing culvert pipe, remove the upstream and downstream portion of the culvert to within 48 inches (1200 millimeters) of the subgrade or embankment slope. Ensure the abandoned pipe is at least 48 inches (1200 millimeters) from a new culvert or structure. Seal the abandoned culvert ends with a tight-fitting plug of concrete at least 6 inches (150 millimeters) thick. Ensure the structure does not entrap water.

Except in excavation areas, backfill and compact cavities left by structure removal with backfill material to the lines and grades of the finished ground. Backfill excavated areas according to Subsection 209.09. Compact backfill according to Subsection 209.10.

(c) Concrete removal in repair areas. Saw cut ¾ inch (19 millimeters) deep along boundaries of repair areas. Use power-driven hand tools to remove existing concrete. Do not damage concrete designated to remain in place.

Where the bond between existing concrete and reinforcing steel is destroyed, remove concrete adjacent to the steel to provide at least ¾-inch (19-millimeter) clearance for the new concrete to bond to the reinforcing steel. Use care to prevent damage to remaining concrete when achieving the final surface.

Clean exposed concrete surfaces that will be in contact with repair material. Provide a residue free surface.

(d) Reinforcing steel. Do not cut or damage reinforcing steel designated to remain in place. Repair or replace damaged bars. Replace deteriorated bars as directed by the CO.

Clean exposed reinforcing steel of coatings or residue that inhibits bonding with the new concrete.

Protect the steel from corrosion and contamination. If the steel becomes corroded or contaminated, reclean the steel before placing concrete.

203.05 Disposing of Material. Dispose of debris, unsuitable material, and excess material as follows:

(a) Remove from project. Recycle or dispose of material legally off the project. Submit a statement documenting the nature and quantity of material processed or sold for recycling. Otherwise, submit a signed copy of the disposal agreement before disposal begins.

(b) Burn. Obtain necessary burning permits. Submit a copy of the burning permits before burning begins.

Burn using high intensity burning processes that produce few emissions. Provide a watchperson during the burning operations.

When burning is complete, extinguish the fire so no smoldering debris remains. Dispose of unburned material according to Subsection 203.05(a).

(c) Bury. Bury debris in trenches or pits in approved areas within the right-of-way when approved. Do not bury debris inside the roadway prism limits, beneath drainage ditches, or in areas subject to free-flowing water.

Place debris in alternating layers of 48 inches (1200 millimeters) of debris covered with 24 inches (600 millimeters) of earth material. Distribute stumps, logs, and other large pieces to form a dense mass and minimize air voids. Cover the top layer of buried debris with at least 12 inches (300 millimeters) of compacted earth. Grade and shape the area. Seed and mulch disposal areas on Government property according to Section 625.

(d) Hazardous material. Submit a copy of disposal permits. Dispose of material according to Federal, state, and local regulations.

Dispose of lead contaminated steel either by transporting to an approved scrap facility for recycling or remelt; or remove and dispose of lead contamination in an appropriate waste facility.

(1) Disposal plan. Submit a detailed disposal plan that includes how material will be handled, loaded, and transported to the disposal facility. Include the name and address of the facility where the material will be taken. Describe steps that will be taken to ensure that lead contamination will be contained throughout the process. Measures may include additional steps or precautions when lifting and handling the steel on site.

(2) Transport and delivery. Include the material safety data sheet (MSDS) with the material to the disposal facility. Ensure that loads transported from the site are adequately contained and covered to prevent dispersion en route to the disposal facility. Submit a copy of the receiving report from the disposal facility specifically acknowledging that the material being delivered is contaminated with lead paint.

(3) Lead paint removal. If the Contractor chooses to salvage the steel members, the paint may be removed subject to the following requirements:

(a) Remove lead contaminated paint in an appropriate containment facility;

(b) Comply with the requirements as listed in Subsection 563.05; and

(c) Manifest and dispose of lead contaminated waste according to the requirements of 40 CFR 260 through 268 – Resource Conservation and Recovery Act (RCRA).

203.06 Acceptance. Removal of structures and obstructions will be evaluated under Subsection 106.02.

Backfilling and compacting cavities left by structures will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Measurement

203.07 Measure the Section 203 pay items listed in the bid schedule according to Subsection 109.02.

Payment

203.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 203 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 204. — EXCAVATION AND EMBANKMENT

Description

204.01 This work consists of excavating material and constructing embankments. This work also includes furnishing, hauling, stockpiling, placing, disposing, sloping, shaping, compacting, and finishing earthen and rocky material.

204.02 Definitions.

(a) Excavation. Excavation consists of the following:

(1) Roadway excavation. Material excavated from within the right-of-way or easement areas, except subexcavation covered in Subsection 204.02(a)(2) and structure excavation covered in Sections 208 and 209. Roadway excavation includes all material encountered regardless of its nature or characteristics.

(2) Subexcavation. Material excavated from below subgrade elevation in cut sections or from below the original ground-line in embankment sections. Subexcavation excludes the work required by Subsection 204.05 or 204.06.

(3) Borrow excavation. Material used for embankment construction that is obtained from outside the roadway prism. Borrow excavation includes unclassified borrow, select borrow, and topping.

(b) Embankment construction. Embankment construction consists of placing and compacting roadway or borrow excavation. This work includes:

(1) Preparing foundation for embankment;

(2) Constructing roadway embankments;

(3) Benching for side-hill embankments;

(4) Constructing dikes, ramps, mounds, and berms; and

(5) Backfilling subexcavated areas, holes, pits, and other depressions.

(c) Conserved topsoil. Excavated material conserved from the roadway excavation and embankment foundation areas that is suitable for growth of grass, cover crops, or native vegetation.

(d) Waste. Excess and unsuitable roadway excavation and subexcavation that cannot be used.

Material

204.03 Conform to the following Subsections:

Select borrow	704.07
Topping	704.05
Unclassified borrow	704.06
Water	725.01(c)

Construction Requirements

204.04 Preparation for Roadway Excavation and Embankment Construction. Clear the area of vegetation and obstructions according to Sections 201 and 203.

Road pioneering may proceed concurrently with excavation and embankment. Maintain drainage during pioneering operations.

204.05 Conserved Topsoil. Conserve topsoil from roadway excavation and embankment foundation areas. Stockpile conserved topsoil in low windrows immediately beyond the rounding limits of cut and embankment slopes or in other approved locations. Separate topsoil from other excavated material.

Place conserved topsoil on completed slopes according to Section 624.

204.06 Roadway Excavation. Excavate as follows:

(a) Rock cuts. Blast rock according to Section 205. Excavate rock cuts to 6 inches (150 millimeters) below subgrade within the roadbed limits. Backfill to subgrade with topping or other suitable material. Compact the material according to Subsection 204.11.

(b) Earth cuts. Scarify earth cuts to 6 inches (150 millimeters) below subgrade within the roadbed limits. Compact the scarified material according to Subsection 204.11.

Dispose of unsuitable or excess excavation material according to Subsection 204.14. Replace shortage of suitable material caused by premature disposal of roadway excavation.

Shape to drain and compact the work area to a uniform cross-section at the end of each day's operations.

204.07 Subexcavation. Excavate material to the required limits. Dispose of unsuitable material according to Subsection 204.14. Take cross-sections according to Section 152. Place backfill material in horizontal layers not exceeding 12 inches (300 millimeters) in compacted thickness and compact according to Subsection 204.11. Prevent unsuitable material from mixing with backfill.

204.08 Borrow Excavation. Use suitable roadway excavation in embankment construction. Do not use borrow excavation when it results in excess roadway excavation. Deduct excess borrow excavation from the total borrow excavation quantity.

Obtain borrow source approval according to Subsection 105.02. Develop and restore borrow sources according to Subsections 105.03 and 105.06. Do not excavate beyond the established limits. When applicable, shape the borrow source to permit accurate measurements when excavation is complete.

204.09 Preparing Foundation for Embankment Construction. Prepare foundation for embankment construction as follows:

(a) Embankment over natural ground. Remove topsoil and break up the ground surface to a minimum depth of 6 inches (150 millimeters) by plowing or scarifying. Compact the ground surface according to Subsection 204.11.

(b) Embankments over an existing asphalt, concrete, or gravel road surface. Scarify gravel roads to a minimum depth of 6 inches (150 millimeters). Scarify or pulverize asphalt and concrete roads to 6 inches (150 millimeters) below the pavement. Reduce particles to a maximum size of 6 inches (150 millimeters) and produce a uniform material. Compact the surface according to Subsection 204.11.

(c) Embankment across ground not capable of supporting equipment. Dump successive loads of embankment material in a uniformly distributed layer to construct the lower portion of the embankment. Limit the layer thickness to the minimum depth necessary to support the equipment.

(d) Embankment on an existing slope steeper than 1V:3H. Cut horizontal steps in the existing slope to a sufficient width to accommodate placement and compaction operations and equipment. Step the slope as the embankment is placed and compacted in layers. Begin each step at the intersection of the original ground and the vertical cut of the previous step.

204.10 Embankment Construction. Incorporate only suitable roadway excavation material into the embankment. When the supply of suitable roadway excavation is exhausted, furnish unclassified borrow to complete the embankment. Construct embankments as follows:

(a) General. At the end of each day's operations, shape to drain and compact the embankment surface to a uniform cross-section. Eliminate ruts and low spots that could hold water.

During all stages of construction, route and distribute hauling and leveling equipment over the width and length of each layer of material.

Compact embankment side slopes with a tamping foot roller, by walking with a dozer, or by over-building the fill and then removing excess material to the final slope line. For slopes 1V:1¾H or steeper, compact the slopes as embankment construction progresses.

(b) Embankment within the roadway prism. Place embankment material in horizontal layers not exceeding 12 inches (300 millimeters) in compacted thickness. Incorporate oversize boulders or rock fragments into the 12-inch (300-millimeter) layers by reducing them in size or placing them individually as required by Subsection 204.10(c). Compact each layer according to Subsection 204.11 before placing the next layer.

Material composed predominately of boulders or rock fragments too large for 12-inch (300-millimeter) layers may be placed in layers up to 24 inches (600 millimeters) thick. Incorporate oversize boulders or rock fragments into the 24-inch (600-millimeter) layer by reducing them in size or placing individual rock fragments and boulders greater than 24 inches (600 millimeters) in diameter as follows:

(1) Reduce rock to less than 48 inches (1200 millimeters) in the largest dimension;

(2) Distribute rock within the embankment to prevent nesting;

(3) Place layers of embankment material around each rock to a depth not greater than that permitted by Subsection 204.10(b). Fill voids between rocks; and

(4) Compact each layer according to Subsection 204.11(a) before placing the next layer.

(c) Embankment outside of roadway prism. When placing embankment outside the staked roadway prism, place material in horizontal layers not exceeding 24 inches (600 millimeters) in compacted thickness. Compact each layer according to Subsection 204.11.

204.11 Compaction. For compaction, use AASHTO T 27 to determine the quantity of material retained on a No. 4 (4.75-millimeter) sieve. Compact as follows:

(a) More than 80 percent retained on a No. 4 (4.75-millimeter) sieve. Adjust the moisture content to a level suitable for compaction. Fill the interstices around rock with earth or other fine material as practical. Use compression-type rollers at speeds less than 6 feet (1.8 meters) per second and vibratory rollers at speeds less than 3 feet (1 meter) per second. Compact each layer of material full width with one of the following and until there is no visible evidence of further consolidation:

(1) Four roller passes of a vibratory roller having a minimum dynamic force of 40,000 pounds (180 kilonewtons) impact per vibration and a minimum frequency of 1000 vibrations per minute;

(2) Eight roller passes of a 20-ton (20-metric ton) compression-type roller; or

(3) Eight roller passes of a vibratory roller having a minimum dynamic force of 30,000 pounds (130 kilonewtons) impact per vibration and a minimum frequency of 1000 vibrations per minute.

Increase the compactive effort for layers deeper than 12 inches (300 millimeters) as follows:

- For each additional 6 inches (150 millimeters) or fraction thereof, increase the number of roller passes in Subsection 204.11(a)(1), by four passes; or
- For each additional 6 inches (150 millimeters) or fraction thereof, increase the number of roller passes in Subsection 204.11(a)(2) and (3), by eight passes.

(b) 50 to 80 percent retained on a No. 4 (4.75-millimeter) sieve. Classify the material according to AASHTO M 145. Adjust the moisture content of material classified A-1 through A-5 to a moisture content suitable for compaction. Adjust the moisture content of material classified A-6 and A-7 to within 2 percent of the optimum moisture content. Use AASHTO T 99 to determine the optimum moisture content of the portion of the material passing a No. 4 (4.75-millimeter) sieve. Multiply this number by the percentage of material passing a No. 4 (4.75-millimeter) sieve, and add 2 percent to determine the optimum moisture content of the material.

Use nonvibratory rollers at speeds less than 6 feet (1.8 meters) per second and vibratory rollers at speeds less than 3 feet(1 meter) per second. Compact each layer of material full width according to Subsection 204.11(a).

(c) Less than 50 percent retained on a No. 4 (4.75-millimeter) sieve. Classify the material according to AASHTO M 145. For material classified A-1 or A-2-4, determine the maximum density according to AASHTO T 180, Method D. For other material classifications, determine the optimum moisture content and maximum density according to AASHTO T 99, Method C.

Adjust the moisture content of material classified A-1 through A-5 to a moisture content suitable for compaction. Adjust the moisture content of material classified A-6 and A-7 to within 2 percent of the optimum moisture content.

Use compression-type or vibratory rollers. Compact each layer of material full width to at least 95 percent of the maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures. When required, use AASHTO T 224 to correct for coarse particles.

204.12 Ditches. Slope, grade, and shape ditches. Remove projecting roots, stumps, rock, or similar matter. Maintain ditches in an open condition and without sticks, and other debris.

Form furrow ditches by plowing or using other acceptable methods to produce a continuous furrow. Place excavated material on the downhill side so the bottom of the ditch is approximately 18 inches (450 millimeters) below the crest of the loose material. Clean the ditch using a hand shovel or other suitable method. Shape to provide drainage without overflow.

204.13 Sloping, Shaping, and Finishing. Complete slopes, ditches, culverts, riprap, and other underground minor structures before placing aggregate courses. Slope, shape, and finish as follows:

(a) Sloping. Leave earth slopes with uniform roughened surfaces, except as described in Subsection 204.13(b), with no noticeable break as viewed from the road. Except in solid rock, round tops and bottoms of slopes including the slopes of drainage ditches. Round material overlaying solid rock to the extent practical. Scale rock slopes.

If a slide or slipout occurs on a cut or embankment slope, remove or replace the material and repair or restore damage to the work. Bench or key the slope to stabilize the slide. Reshape the cut or embankment slope to an acceptable condition.

(b) Stepped slopes. Where required, construct steps on slopes of 1⅓V:1H to 1V:2H. Construct the steps approximately 18 inches (450 millimeters) high. Blend the steps into natural ground at the end of the cut. If the slope contains non-rippable rock outcrops, blend steps into the rock. Remove loose material found in transitional area. Except for removing large rocks that may fall, scaling stepped slopes is not required.

(c) Shaping. Shape the subgrade to a smooth surface and to the cross-section required. Shape slopes to gradually transition into slope adjustments without noticeable breaks. At the ends of cuts and at intersections of cuts and embankments, adjust slopes in the horizontal and vertical planes to blend into each other or into the natural ground.

(d) Finishing. Remove material larger than 6 inches (150 millimeters) from the top 6 inches (150 millimeters) of the roadbed. Remove unsuitable material from the roadbed, and replace it with suitable material. Finish roadbeds that are compacted according to Subsection 204.11(b) and (c) to within ±0.05 foot (±15 millimeters) of the staked line and grade. Finish roadbeds that are compacted according to Subsection 204.11(a) to within ±0.10 foot (±30 millimeters) of the staked line and grade. Finish ditch cross-sections to within ±0.10 feet (±30 millimeters) of the staked line and grade. Maintain proper ditch drainage.

204.14 Disposal of Unsuitable or Excess Material. Dispose of unsuitable or excess material according to Subsection 203.05(a).

When there is a pay item for waste, shape and compact the waste material in its final location. Do not mix clearing or other material not subject to payment with the waste material.

204.15 Acceptance. See Table 204-1 for sampling, testing, and acceptance requirements.

Material for embankment and conserved topsoil will be evaluated under Subsections 106.02 and 106.04.

Excavation and embankment construction will be evaluated under Subsections 106.02 and 106.04.

Subexcavation will be evaluated under Subsections 106.02 and 106.04.

Measurement

204.16 Measure the Section 204 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

(a) Roadway excavation. Measure roadway excavation in its original position as follows:

(1) Include the following volumes in roadway excavation:

(a) Roadway prism excavation;

(b) Rock material excavated and removed from below subgrade in cut sections;

(c) Unsuitable material below subgrade and unsuitable material beneath embankment areas when a pay item for subexcavation is not listed in the bid schedule;

(d) Ditches, except furrow ditches measured under a separate pay item;

(e) Conserved topsoil;

(f) Borrow material used in the work when a pay item for borrow is not listed in the bid schedule;

(g) Loose scattered rocks removed and placed as required within the roadway;

(h) Conserved material taken from pre-existing stockpiles and used in Section 204 work, except topsoil measured under Section 624; and

(i) Slide and slipout material not attributable to the Contractor's method of operation.

(2) Do not include the following in roadway excavation:

(a) Overburden and other spoil material from borrow sources;

(b) Overbreakage from the backslope in rock excavation;

(c) Water or other liquid material;

(d) Material used for purposes other than required;

(e) Roadbed material scarified in place and not removed;

(f) Material excavated when stepping cut slopes;

(g) Material excavated when rounding cut slopes;

(h) Preparing foundations for embankment construction;

(i) Material excavated when benching for embankments;

(j) Slide or slipout material attributable to the Contractor's method of operation;

(k) Conserved material taken from stockpiles constructed at the option of the Contractor;

(l) Material excavated outside the established slope limits; and

(m) Road pioneering for the convenience of the Contractor.

(3) When both roadway excavation and embankment construction pay items are listed in the bid schedule, measure roadway excavation only for the following:

(a) Unsuitable material below subgrade in cuts and unsuitable material beneath embankment areas when a pay item for subexcavation is not listed in the bid schedule;

(b) Slide and slipout material not attributable to the Contractor’s method of operations; and

(c) Drainage ditches, channel changes, and diversion ditches.

(b) Unclassified borrow, select borrow, and topping. When measuring by the cubic yard (cubic meter) measure in its original position. If borrow excavation is measured by the cubic yard (cubic meter) in-place, take initial cross-sections of the ground surface after stripping overburden. Upon completion of excavation and after the borrow source waste material is returned to the source, retake cross-sections before replacing the overburden.

Do not measure borrow excavation until suitable roadway excavation is depleted.

(c) Embankment construction. Measure embankment construction in its final position. Do not make deductions from the embankment construction quantity for the volume of minor structures.

(1) Include the following volumes in embankment construction:

(a) Roadway embankments;

(b) Material used to backfill subexcavated areas, holes, pits, and other depressions;

(c) Material used to restore obliterated roadbeds to original contours; and

(d) Material used for dikes, ramps, mounds, and berms.

(2) Do not include the following in embankment construction:

(a) Preparing foundations for embankment construction;

(b) Adjustments for subsidence or settlement of the embankment or of the foundation on which the embankment is placed; and

(c) Material used to round fill slopes.

(d) Rounding cut slopes. Measure rounding cut slopes horizontally along the centerline of the roadway.

(e) Waste. Measure waste by the cubic yard (cubic meter) in its final position. Take initial cross-sections of the ground surface after stripping over-burden. Upon completion of the waste placement, retake cross-sections before replacing overburden.

(f) Slope scaling. Measure slope scaling by the cubic yard (cubic meter) in the hauling vehicle.

(g) Subexcavation. Measure subexcavation by the cubic yard (cubic meter) in its original position.

Payment

204.17 The accepted quantities will be paid at the contract price per unit of measurement for the Section 204 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 204-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Source								
Topping (704.05)	Measured and tested for conformance (106.04 & 105)	Classification[(1)]	–	AASHTO M 145	1 per soil type and source of material	Source of material	Yes	Before using in work
Unclassified borrow (704.06)	"	"	–	"	"	"	"	"
Select borrow (704.07)	"	"	–	"	"	"	"	"
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"

Table 204-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Production								
Topping (704.05)	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D[(2)] or T 99, Method C[(2)]	1 per soil type, but not less than 1 per each 13,000 yd^3 (10,000 m^3)	Processed material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 (3000 m^2), but not less than 1 per layer	In-place	No	Before placement of next layer
Unclassified borrow (704.06)	"	Moisture-density	–	AASHTO T 180, Method D[(2)] or T 99, Method C[(2)]	1 per soil type, but not less than 1 per each 13,000 yd^3 (10,000 m^3)	Processed material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 (3000 m^2), but not less than 1 per layer	In-place	No	Before placement of next layer

Table 204-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Production (continued)								
Select borrow (704.07)	Measured and tested for conformance (106.04)	Classification	–	AASHTO M 145	1 per soil type, but not less than 1 for each day of production	Processed material	Yes	Before using in work
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"
		Moisture-density	–	AASHTO T 180, Method D[(2)] or T 99, Method C[(2)]	1 per soil type, but not less than 1 per each 13,000 yd^3 (10,000 m^3)	"	"	"
		Density	–	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 (3000 m^2), but not less than 1 per layer	In-place	No	Before placement of next layer

Table 204-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Production (continued)								
Earth embankment (204.11)	Measured and tested for conformance (106.04)	Classification	–	AASHTO M 145	1 per soil type	Source of material	Yes	Before using in work
		Moisture-density	–	AASHTO T 180, Method D[(2)] or T 99, Method C[(2)]	1 per soil type, but not less than 1 per each 13,000 yd^3 (10,000 m^3)	"	"	"
		Density	–	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 (3000 m^2), but not less than 1 per layer	In-place	No	Before placement of next layer
Top of subgrade (204.11)	"	Density	–	AASHTO T 310 or other approved procedures	1 per 2500 yd^2 (2000 m^2), but not less than 1 per layer	In-place	No	Before placement of next layer
Finished Product								
Roadbed (204.13)	Measured and tested for conformance (106.04)	Final line & grade	–	Field measured	Determined by the CO	Determined by the CO	No	Before placement of next layer

(1) Not required when using Government-provided source.
(2) Minimum 5 points per proctor.

Section 205. — ROCK BLASTING

Description

205.01 This work consists of rock fragmentation blasting using production and controlled blasting techniques to construct engineered rock cuts.

205.02 Definitions.

(a) Production blasting. Blasting using widely spaced blast holes that typically contain larger explosive charges to expedite movement and fragmentation for rock removal.

(b) Controlled blasting. Blasting that includes presplit blasting and cushion blasting hole techniques. Controlled blasting uses closely-spaced and carefully aligned blast holes that typically contain lighter charges than production holes to produce stable, aesthetically pleasing rock faces with minimal blast damage. Controlled blast holes are the first row of blast holes, normally located within 24 inches (600 millimeters) of the top of the staked slope.

(1) Presplit blasting. Presplit blasting detonates closely spaced backslope holes before drilling for production blasting or before detonating the production blasting holes to produce a highly controlled, smooth cut face.

(2) Cushion blasting. Cushion blasting is similar to presplitting, except that the detonation of the cushion holes along the backslope is detonated immediately after the detonation of the production and buffer holes, generally resulting in a more natural cut face appearance.

Construction Requirements

205.03 Regulations. Comply with Federal, state, and local regulations for the purchase, transportation, storage, and use of explosive material. Federal regulations include the following:

(a) Safety and health. OSHA, 29 CFR Part 1926, Subpart U.

(b) Storage, security, and accountability. Bureau of Alcohol, Tobacco, and Firearms (BATF), 27 CFR Part 555, *Commerce in Explosives*.

(c) Shipment. DOT, 49 CFR Parts 171-179, 390-397.

(d) National Park Service. For projects in National Park Service lands, comply with National Park Service Director’s Order No. 65, *Explosives Use and Blasting Safety*.

205.04 Qualifications. Submit the following for approval at least 14 days before drilling and blasting operations begin:

(a) Blaster-in-charge. Furnish an individual who can directly supervise the drilling and blasting crew during drilling, loading, and detonation of charges. Include the following:

(1) Name of blaster-in-charge;

(2) A résumé showing at least 5 years' experience as a blaster-in-charge on projects with similar work;

(3) Copy of a valid blaster license accepted by the state where the project is located for the type of blasting required; and

(4) Five references with knowledge of qualifications and reliability. Include name, relationship, and current telephone number for each reference.

(b) Blasting crew personnel. Names of personnel and evidence they have completed at least 24 hours of blasting safety training in the last 5 years' or have at least 2 years' of blasting experience.

(c) Drillers. Names and evidence they are proficient in drilling methods required to perform the work.

(d) Vibration specialist. Name and résumé showing at least 5 years' experience as a vibration specialist on projects with similar work.

205.05 Blasting Plans. Submit proof of applicable permits, licenses, and a general blasting plan signed by the blaster-in-charge at least 14 days before drilling and blasting operations. Blasting plans are not required for boulder reduction blasts (mudcapping or blockholing).

(a) General blasting plan. Submit a general blasting plan for review and approval by the CO. Include the following:

(1) Procedures and safety precautions for transporting, handling, storing, loading, and detonating explosives, conducting pre- and post-blast surveys, monitoring blasts, managing misfires, and removing and disposing of excess explosives.

(2) Explosives transportation and storage plan, including:

(a) Name, address, and telephone number of explosives suppliers;

(b) Description and license number of explosives transport vehicles, routes to be traveled, proposed hours of travel, and driver qualifications;

(c) Magazine and day-box locations;

(d) Explosives and accessories inventory system; and

(e) Contact information for the person responsible for security of project blasting material and supplies.

(3) Area security plan including explosives and general site security, methods of site communication, pre- and post-blast signage and audible signaling systems, road closure requirements, and pre-blast notification for affected agencies or entities.

(4) Manufacturer's MSDS and product data sheets for proposed explosives, primers, initiators, and related blasting devices and accessories.

(5) Excavation plans and equipment lists for pre-blast scaling and pioneered access roads, and benches for drilling and blasting operations.

(6) Typical plan and section views for both production and controlled blasting, including stationing intended for each typical plan, maximum blast length, free face, burden, hole spacing, hole inclination, hole depth, hole diameter, stemming depth, subdrill depth, powder factor, charge per delay, initiation method and sequence, and delay times.

(7) Methods for limiting dust and noise.

(8) Fire watch plan including number of post-blast observers and duration of the fire watch.

(9) Contingency plan for blast flyrock containment, including the names and qualifications of those responsible for preparing containment system designs.

Do not deliver explosives to the project until the general blasting plan is accepted. Submit revisions and updates within 48 hours of changes in the above information.

(b) Site-specific blasting plans and general plan revisions and updates. Submit site-specific blasting plans after approval of the general blasting plan or at times there is a change in drilling and blasting methods provided in the general blasting plan. Allow 3 days for approval. Do not begin drilling until the plan is approved. Include the following:

(1) Proposed excavation sequence;

(2) Station limits and plan view of the proposed blast, showing how the proposed blast fits into the lift excavation sequence;

(3) Elevations of the tops and bottoms of each lift;

(4) Scaled drawings for each blast showing access, containment, plan and section views of drill patterns, clearing limits, free face, burden, blast hole locations, blast hole spacing, subdrill depths, lift height, blast hole diameters, and blast hole angles;

(5) Loading diagram for each blast showing powder factor, charge per delay, type and quantity of explosives, primers, initiators, locations of decking, and range of stemming depths for substantial variations within the drill pattern;

(6) Initiation method and sequence of blast holes for each blast. Include delay times, delay system, and down hole firing times;

(7) Flyrock control measures;

(8) Estimated volume of in-place rock to be blasted. Include the total length of production and controlled blast hole;

(9) Location and orientation of significant joints, fractures, faulting, bedding planes or other rock mass structural features to be accounted for in the site-specific blasting plan; and

(10) Post-blast rockfall containment designs and procedures.

205.06 Pre-Blast Condition Survey and Vibration Monitoring and Control. The Contractor is responsible for damage resulting from blast related ground vibrations and air-blast over-pressures. Determine the need for vibration monitoring depending on soil and rock conditions, blasting parameters as outlined in the blasting plan, and proximity of buildings, structures, utilities, and sensitive natural features that may be subject to damage from ground vibrations or air-blasts. If vibration monitoring is required conform to the following requirements:

(a) If not specified in the contract, establish referenceable blasting criteria for buildings, structures, utilities and natural features that conform to federal, state, or local regulations. Present blasting criteria in terms of distance of the facility or feature from blasting, maximum allowable peak particle velocity limits versus structure type, maximum allowable peak particle velocity versus peak frequency, and air over-pressure structure damage limits.

(b) Conduct a pre-blast condition survey of nearby buildings, structures, utilities, and natural features potentially damaged by blasting-related ground vibrations or air-blast. Document the natural frequency of each affected structure or feature. Use a survey method acceptable to the Contractor's insurance company. Submit a copy of pre-blast condition survey records with the site-specific blasting plans for CO review.

(c) Control ground vibrations and air-blast over-pressures with properly designed delay sequences and maximum allowable charge weights per delay. Verify allowable charge weights per delay by conducting representative trial blasts and measuring ground vibrations and air-blast over-pressure levels. Conduct test blasts with blast plan modifications that limit ground vibrations and air-blast over-pressures to levels that will not cause damage to nearby buildings, structures, utilities and natural features as determined by the vibration specialist.

(d) When ground vibration or air-blast damage is possible, monitor each blast with digital recording seismographs and air-blast monitoring equipment calibrated within the last year and approved by the CO. Locate monitoring equipment as directed by the vibration specialist. Place at least three recording stations between the blast area and closest susceptible structures, utilities, or natural features. Place at least one station on the structure. For ground vibration monitoring, use seismographs capable of recording particle velocity, displacement and acceleration for three mutually perpendicular components of vibration. Use a seismograph with a lower linear response limit over the response frequency range of not more than 2 hertz and upper limit not less than 50 hertz. Use sensors having lower thresholds not higher than 0.005 inches (0.13 millimeters), 0.05 inches (1.3 millimeters) per second, and 0.02g. Use seismographs capable of producing a permanent digital time history file for each ground motion episode.

Ensure blasting operations incorporate collected data and findings from vibration monitoring by having the vibration specialist interpret seismograph and air-blast records.

205.07 Test Blasting. Before beginning full-scale drilling and blasting, demonstrate adequacy of the site-specific blasting plan by drilling, blasting, and excavating a test blast of up to 100 cubic yards (75 cubic meters) with proposed containment measures in-place. Conduct the test at an approved location within the planned excavation area.

A test blast is unacceptable when it results in oversized fragmentation, excessive or uncontrolled flyrock, potentially damaging ground vibrations or air-blasts, unplanned overbreak, excessive damage to the final rock face, or unwanted overhangs. When a test blast is unacceptable, revise the site-specific blasting plan and conduct an additional test blasts until the combination of blast hole pattern spacing, controlled blast hole alignment, and charges produce acceptable results.

205.08 Blasting. Use explosives and initiating devices less than 1-year old. Locate explosives magazines at sites approved by the CO.

Inspect the pre-blast area and submit the proposed extent of pre-blast clearing and scaling for approval.

Use angle- or fan-drilled holes as needed during initial pioneering operations to obtain the desired face. Controlled blasting requirements are applicable to pioneering work.

Record and maintain a log of each blast hole drilled identifying the depth, color, and character of the cuttings, penetration rate, hole collar location and hole orientation, and other pertinent information. Before initiating the blast, prepare a blast plan map and submit it showing designated hole numbers along with individual hole logs completed, dated and signed by the driller.

Ensure blast holes are free of obstructions for the entire depth before placing charges. Take necessary precautions when placing charges so, caving of material from the walls of the holes and the hole collar will not occur.

Mitigate uncontrolled gas pressure loss during blasting and excessive blast noise by stemming the upper portion of blast holes with appropriate dry granular material passing the ½-inch (12.5-millimeter) sieve. Do not stem holes with drill cuttings.

Blast according to the approved site-specific blasting plan. Use blasting mats, rockfall containment systems, and other protective devices to prevent damage to surrounding features.

Stop drilling and blasting operations, and submit a revised site-specific blasting plan according to Subsection 205.05(b), when the following occur:

- Slopes are unstable;
- Slopes exceed overbreak tolerances;
- Unwanted overhangs, ridges, or ledges are created;
- Excessive blast damage occurs;
- Poor fragmentation results in oversize material requiring secondary blasting and rehandling;
- Safety of the public is jeopardized;
- Property or natural features are endangered;
- Excessive or uncontrolled flyrock is generated;
- Excessive ground vibration or air-blast over-pressures occurs where damage to buildings, structures, utilities or natural features is possible; or
- Desired slope or rock face conditions are not produced.

Remove or stabilize cut face rock that is loose, hanging, or potentially dangerous after each blast. Scale by methods approved by the CO. Leave minor irregularities or surface variations in place if they do not create a hazard. Excavate and remove material outside of the planned neat line slopes which is unstable and constitutes a potential hazard. Do not drill the next lift until slope stabilization and blast cleanup work is complete.

(a) Production blasting. When conducting cushion blasting or presplitting, drill a lighter-loaded buffer row of production holes on a parallel plane adjacent to the controlled blast line to minimize blast damage to the final slope.

Drill production blast holes a maximum of 4 inches (100 millimeters) in diameter to a sufficient depth such that unbroken rock does not extend above the finish surface. Drill production blast holes to the design depth. If more than 5 percent of the production blast holes in a lift do not conform to the design depth requirements, redrill the shallow holes to the proper. Except when subdrilling, do not drill production blast holes, below the base plane of the controlled blast holes.

Drill production blast holes within two drill hole diameters of the planned collar location. If more than 5 percent of the drill hole collars in a lift are out of tolerance, fill each hole outside of the location tolerance with crushed stone and redrill at the proper.

Detonate production holes in a controlled delay sequence.

(b) Controlled blasting. Use angled or fan drilled holes for pioneering the tops of rock cuts and preparing working platforms. Use equipment or methods approved by the CO for areas not accessible to track drill equipment.

Before drilling, completely remove overburden, soil, and loose or decomposed rock along the top of the excavation for a distance of at least 30 feet (9 meters) beyond the end of the production hole drilling limits, or to the end of the cut.

Use controlled blasting to form the final cut face on rock cuts where the staked slope ratio is 1⅓V:1H or steeper and the slope height is more than 10 feet (3 meters) above the ditch grade.

Use drilling equipment that accurately controls the angle the drill as it enters the rock. Select a lift height and conduct drilling operations so the blast hole spacing and down-hole alignment does not vary more than 8 inches (200 millimeters) from the proposed spacing and alignment. If more than 5 percent of the holes exceed the variance, reduce the lift height and modify drilling operations until the holes are within tolerance.

Drill holes a maximum of 3 inches (75 millimeters) in diameter and within 3 inches (75 millimeters) of the staked collar location. Fill and redrill blast holes outside of the location tolerance when more than 5 percent of the hole collars in a lift are outside of the location tolerance Use crushed stone to fill the blast holes before redrilling. Drill the controlled blast hole line at least 30 feet (9 meters) beyond loaded production holes or to the end of the cut.

Do not exceed 30 feet (9 meters) for bench height or drill hole length. Limit subdrilling of holes to one-half of the hole spacing or 24 inches (600 millimeters) whichever is deeper.

Offset lifts up to 24 inches (600 millimeters) horizontally to allow for drill equipment clearance. Remove benches resulting from the drilling offset.

Compensate for drift that may occur in the upper lifts. Adjust the drill inclination angle or the initial drill collar location to obtain the required typical section. Limit drilling to one-half of the hole spacing or 24 inches (600 millimeters) whichever is deeper.

Do not use bulk ammonium nitrate and fuel oil for controlled blasting. Only standard explosives manufactured specifically for controlled blasting will be used in controlled blast holes, unless approved by the CO.

Maximum diameter of explosives used in controlled blast holes will be no greater than one-half the diameter of the presplit hole.

(1) Presplitting. Do not presplit final slopes and rock faces. When presplitting is allowed in the plans, either presplit along the slope face before drilling for production blasting or presplit the slope face in conjunction with production blasting.

(2) Cushion blasting. Perform cushion blasting to produce rough, natural looking rock slopes. Use the existing geologic structure to create rock surfaces, terraces, and ridges that blend with adjacent undisturbed rock faces. Preserve existing rock outcrops to the extent practical to vary the cut face slope, composition, color, and texture.

(3) Horizontal blasting. With CO approval only, use horizontal drill holes instead of or in conjunction with vertical cushion blasting drill holes to produce natural looking rock slopes, mitigate drill hole traces, assist pioneering access for drill bench excavation, or to excavate sliver rock cuts where vertical drilling is not feasible.

When required, preserve or create soil pockets and ledges for revegetation. Locate, size, and shape these features to replicate the vegetated areas on the undisturbed rock faces. Incorporate these features into the site-specific blasting plans. Do not create features by overshooting or selectively removing damaged rock.

205.09 Reporting.

(a) Post-blast. Prepare an post-blast report for blasts. Submit the report within 3 days following a blast and before drilling for the next blast. Include the following:

(1) Results of the blast (overbreak, blast damage, noise levels, flyrock, drill trace retention, fragmentation, material containment, material rehandling requirements, and misfires);

Submit proposed changes for future site-specific blasting plans that will produce acceptable results if blasting objectives were not met. Submit proposed repairs or stabilization plans for unstable or blast damaged backslopes;

(2) A detailed blasting plan amended to show significant changes in pattern, loading, or timing;

(3) Drilling logs for each hole completed (dated and signed by the driller) that identify the depth, color, and character of the cuttings. Also include the penetration rate, hole collar location, hole orientation, and conditions that adversely affected drilling or explosives loading operations;

(4) Depth measurements of production and controlled blast holes;

(5) A drawing or sketch showing the direction of blast, the face, or faces, hole numbers, and the physical blast layout;

(6) Measurement of overbreak quantities following lift mucking;

(7) Date and time of loading and detonating the blast; and

(8) Name and signature of the blaster-in-charge.

(b) Vibration and air-blast reporting. Submit a vibration and air-blast report within 3 days of a blast for review by the CO. Do not drill until directed by the CO. Include the following:

(1) Type of vibration or air-blast recording station used and instrument identification numbers;

(2) Name of vibration specialist observing the blast and interpreting vibration and air-blast data;

(3) Blast identification number and location of blast;

(4) Distance and direction of ground vibration and air-blast over-pressure recording stations from the blast area;

(5) Type of material ground vibration recording stations were sitting on at the time of the blast;

(6) Maximum applicable charge weight per delay;

(7) Peak displacement, particle velocity and frequency recorded at each ground vibration sensor location;

(8) Peak over-pressure recorded at each air-blast sensor location;

(9) Dated and signed copy of all instrument records;

(10) Post-blast condition survey noting changes from the pre-blast survey; and

(11) Comments on success of the blast in terms of adherence to established ground vibration or air-blast criteria and management practices.

When failing to meet ground vibration and air-blast criteria and management objectives, submit proposed changes to future site-specific blasting plans that will produce acceptable results.

(c) Close-out. Submit a written statement signed by the blaster-in-charge certifying:

(1) Blastholes loaded with explosive material have been either detonated or unloaded and disposed of properly; and

(2) Blasting is complete and explosive material has been removed from the project site.

205.10 Acceptance. Material for rock blasting will be evaluated under Subsections 106.02 and 106.03.

Rock blasting will be evaluated under Subsections 106.02 and 106.04.

Measurement

205.11 Measure the Section 205 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring controlled blasting by the square foot (square meter), measure the face blast as shown in the blasting plan.

When measuring controlled blast holes by the linear foot (meter), measure the actual length of drilling recorded in the post blast reports. Controlled blast hole includes the row of holes lying closest to the trim line.

Do not measure presplit blast holes whose misalignment is more than 8 inches (200 millimeters.)

Do not measure production blast holes.

Payment

205.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 205 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 206. — RESERVED

Section 207. — EARTHWORK GEOSYNTHETICS

Description

207.01 This work consists of furnishing and installing geotextile in separation, stabilization, and filter applications, geogrid in stabilization applications, and geomembrane in moisture barrier applications.

Geosynthethics are designated according to the tables in Section 714.

Material

207.02 Conform to the following Subsections:

Geomembrane	714.05
Geotextile	714.01
Stabilization geogrid	714.03

Construction Requirements

207.03 General. Identify, store, and handle geosynthetics according to ASTM D4873 and the manufacturer's recommendations. Elevate and protect geosynthetic rolls with a waterproof cover if stored outdoors. Limit geosynthetics exposure to less than 10 days of ultraviolet radiation.

For seams sewn on-site, conform to the manufacturer's recommendations. Obtain approval of the seam before installation. Use thread consisting of high strength polypropylene or polyester. Do not use nylon thread. Use thread that is resistant to ultraviolet radiation and a contrasting color to the geotextile.

Submit a seam assembly description and a sample of the sewn material at least 14 days before installation when geosynthetic joints are sewn as follows:

(a) Assembly description. Include the seam type, seam allowance, stitch type, sewing thread tex ticket numbers and types, stitch density, and stitch gauge.

(b) Sewn seam samples. Sew seam samples using the same equipment and procedures used to sew production seams. Submit samples that have at least 6 feet (1.8 meters) of sewn seam and are at least 5 feet (1.5 meters) wide. If production seams are sewn in both the machine and cross-machine directions, provide sewn seam samples that are oriented in both the machine and cross-machine directions.

Replace or repair geosynthetic that is torn or punctured. Remove the damaged area and place a patch of the same type of geosynthetic overlapping 36 inches (900 millimeters) beyond the damaged area or sew a seam around the damaged area.

207.04 Geotextile and Geogrid Separation and Stabilization Applications.

(a) Surface preparation. Before placing the geotextile, geogrid, or both, prepare the surface as follows:

(1) Existing ground. Cut trees and shrubs flush with the ground surface. Do not remove the topsoil and vegetation mat. Clear the area of vegetation and obstructions according to Sections 201 and 203. Remove sharp objects and large rocks. Fill depressions or holes with suitable material to provide a smooth surface.

(2) Subgrade. Prepare the subgrade according to Subsections 204.13(c) and (d).

(3) Subexcavation. Perform subexcavation according to Subsection 204.07.

(b) Geotextile or geogrid placement. Place geogrid on top of geotextile when both are shown at the same elevation in the plans. Place the geosynthetic smooth, taut, and wrinkle free on the underlying surface. Conform to curves. Overlap in the direction of construction. Overlap at least 24 inches (600 millimeters) at the ends and sides of adjoining sheets or sew the joints according to the manufacturer's recommendations. Do not place longitudinal overlaps below anticipated wheel loads. Hold the geosynthetic in place with pins, staples, or piles of cover material.

(c) Backfilling.

(1) First layer placement and compaction. End dump the backfill material onto the geotextile or geogrid from the edge of the geosynthetic or from previously placed cover material. Do not operate equipment directly on the geosynthetic. Spread the end-dumped pile of cover material maintaining a 12 inch (300 millimeters) lift over the geosynthetic. Avoid sudden stops, starts, or turns of the construction equipment. Fill ruts from construction equipment with additional cover material. Do not blade material down to remove ruts. If rutting exceeds 3 inches (75 millimeters) during placement, decrease the construction equipment size, decrease the equipment weight, or increase the first lift thickness as directed by the CO.

Compact according to Subsection 204.11. Do not use sheepsfoot or studded compaction equipment. Compact the cover material with pneumatic-tire or nonvibratory smooth drum rollers.

(2) Subsequent layer placement and compaction. Place subsequent layers according to Subsection 204.10.

Compact according to Subsection 204.11. Vibratory rollers may be used unless pumping or foundation failures occur. Repair damaged areas and then use only nonvibratory rollers.

207.05 Reinforcement Geotextile and Geogrid. See Section 261 for reinforcement geotextile and geogrid placement.

207.06 Geotextile Filter Applications.

(a) Geotextile placement. For slope or wave protection, place the long dimension of the geotextile down the slope. For stream bank protection, place the long dimension of the geotextile parallel to the centerline of the channel.

Overlap or sow seams at the ends and sides of adjoining sheets.

(1) Overlapping. Overlap the uphill or upstream sheet over the downhill or downstream sheet. For above water applications, overlap the geotextile at least 12 inches (300 millimeters). For underwater applications, overlap the geotextile at least 36 inches (900 millimeters).

(2) Sewing. Sew the geotextile seam according to the manufacturer's recommendations.

Offset end joints of adjacent sheets at least 5 feet (1.5 meters). Use key trenches or aprons at the crest and toe of slopes to hold the geotextile in place. As an alternative use anchor pins, at least 18 inches (450 millimeters) long and spaced at 36 inch (900 millimeters) centers to hold the geotextile sheets in place.

(b) Backfilling. Place aggregate, slope protection, or riprap on the geotextile starting at the toe of the slope and proceeding upward. Place riprap onto the geotextile from a height of less than 12 inches (300 millimeters). Place slope protection rock or aggregate backfill onto the geotextile from a height less than 36 inch (900 millimeters). Do not allow stones weighing more than 100 pounds (45 kilograms) to roll down the slope. In underwater applications, place the geotextile and cover material in the same day.

207.07 Geomembrane Applications. Submit a geomembrane installation plan at least 10 days before installing the geomembrane. Include a drawing of the panel layout identifying the location of seams. Include a seam detail and a written description of the seaming procedure.

(a) Surface preparation. Provide a smooth, flat, firm, unyielding foundation for the geomembrane with no sudden, sharp, or abrupt changes or break in grade. Remove rocks, stones, sticks, sharp objects, and debris protruding more than ½ inch (13 millimeters) above the prepared surface.

(b) Geomembrane placement. Orient seams parallel to the line of maximum slope. Use sandbags or piles of cover material to hold the geomembrane in place. Do not drive equipment directly on the geomembrane.

(c) Backfilling. Place backfill material within the same work shift that the geomembrane is installed. End dump backfill material onto the edge of previously placed cover material and roll it into place. Do not push material along the geomembrane which can result in damage or wrinkling.

207.08 Acceptance. Geosynthetics will be evaluated under Subsection 106.03. Submit a production certification with each shipment of geosynthetics.

Geosynthetic installation will be evaluated under Subsections 106.02 and 106.04.

Sewn joints will be evaluated under Subsection 106.02.

Measurement

207.09 Measure the Section 207 pay items listed in the bid schedule according to Subsection 109.02.

When measuring geosynthetics by the square yard (square meter), measure on the plane parallel to the slope face.

Do not measure overlapping material.

Payment

207.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 207 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 208. — STRUCTURE EXCAVATION AND BACKFILL FOR SELECTED MAJOR STRUCTURES

Description

208.01 This work consists of excavating material for the construction of selected structures. This work also includes preserving channels, shoring and bracing, constructing cofferdams, sealing foundations, dewatering, preparing foundations, backfilling, and subsequent removal of safety features and cofferdams.

Material

208.02 Conform to the following Section and Subsections:

Foundation fill	704.01
Neat hydraulic cement grout	725.13(a)(2)
Structural backfill	704.04
Structural concrete	552

Construction Requirements

208.03 General. Follow OSHA safety regulations 29 CFR, Part 1926, Subpart P, *Excavations* for sloping the sides of excavations, using shoring and bracing, and using other safety features. When sides of excavations are sloped for safety considerations, submit one copy of the design that demonstrates conformity with OSHA regulations. Where support systems, shield systems, or other protective systems are to be used, design the shoring according to Section 562. Submit drawings and construction details according to Subsection 104.03.

Clear the area of vegetation and obstructions according to Sections 201 and 203.

Request approval from the CO as to the character and suitability of the foundation material when the excavation is complete. Provide a firm foundation of uniform density throughout its length and width.

Saw cut existing pavements or concrete structures adjacent to the area to be excavated that are designated to remain.

Where necessary, blast rock according to Section 205.

Conserve suitable material for structural backfill from excavated material. Do not deposit excavated material in or near a waterway. Do not stockpile excavated material or allow equipment closer than 24 inches (600 millimeters) from the edge of the excavation. Use suitable material in embankment construction when approved. Dispose of unsuitable or excess material according to Subsection 204.14.

Remove safety features when no longer necessary. Remove shoring and bracing to at least 24 inches (600 millimeters) below the surface of the finished ground.

208.04 Channel Preservation. Perform work in or next to a running waterway as follows:

(a) Excavate and conserve material inside cofferdams, sheeting, or other separations (such as dikes or sandbags);

(b) Do not disturb the natural bed of the waterway adjacent to the work; and

(c) Backfill the excavation to original ground-line with conserved material.

208.05 Cofferdams. Use cofferdams when excavating under water or when the excavation is affected by groundwater.

Submit drawings showing proposed methods and construction details of cofferdams according to Subsection 104.03 and Section 562. Design and construct cofferdams that conform to the following:

(a) Extend below the bottom of the footing;

(b) Brace to withstand pressure without buckling and secured in place to prevent tipping or movement;

(c) Construct watertight as practical;

(d) Provide sufficient clearance for the placement of forms and the inspection of their exteriors;

(e) Provide for dewatering;

(f) Protect fresh concrete from damage; and

(g) Prevent damage to the foundation by erosion.

Remove cofferdam material down to the natural bed of the waterway or to the top of seal, whichever is lower. Remove cofferdam material outside the waterway to at least 24 inches (600 millimeters) below the surface of the finished ground.

208.06 Foundation Seal. Seal the foundation area from water by placing seal concrete when the area cannot be pumped reasonably free of water. Design seal concrete mix according to Subsection 552.03.

Furnish and place seal concrete according to Section 552. Maintain the water level inside the cofferdam at the same level as the water outside the cofferdam while placing a foundation seal. Vent or port the cofferdam at low water level when a foundation seal is placed in tidal water.

Do not dewater a concrete-sealed cofferdam until the seal concrete strength is sufficient to withstand the hydrostatic pressure.

208.07 Dewatering. Remove water as necessary to perform the work. Dispose of water according to Federal, state, and local regulations.

208.08 Foundation Preparation. Prepare foundations as follows:

(a) Footings placed on bedrock. Excavate to the specified elevation. Clean the foundation surface of deleterious material. Clean and grout seams and crevices. Place foundation fill to provide a level bearing pad for footing.

(b) Footings placed on an excavated surface other than bedrock. Excavate material to foundation grade and compact the foundation before footing is placed.

(c) Footings keyed into undisturbed material. Excavate the foundation to the limits of the footing and compact the foundation. Where material does not stand vertically, fill the space between the limits of the footing and the undisturbed material with concrete. Fill only to the top of the excavation if the excavation is below the top of the footing. Concrete placed against steel sheet piles in cofferdams is considered as being against undisturbed material.

(d) Unstable material below footing elevation. Excavate unstable material below foundation grade as directed by the CO and backfill with foundation fill. Place foundation fill in horizontal layers that do not exceed 6 inches (150 millimeters) in compacted thickness. Compact each layer according to Subsection 208.10.

(e) Foundations using piles. Where foundation seals are required drive the piles before placing seal concrete unless otherwise specified. Remove loose and displaced material and reshape the bottom of the excavation to the foundation elevation. Grade and compact the bed to receive the footing.

208.09 Backfill. Place structural backfill in horizontal layers that do not exceed 6 inches (150 millimeters) in compacted thickness. Compact each layer according to Subsection 208.10.

Place structural backfill layers evenly on all sides of the structure as appropriate. Extend each layer to the limits of the excavation or to natural ground.

Do not place structural backfill against concrete until 80 percent of the design strength is achieved.

Backfill in or next to a running waterway according to Subsection 208.04.

208.10 Compacting. Determine optimum moisture content and maximum dry density according to AASHTO T 99, Method C. Adjust the moisture content of the backfill material to a moisture content suitable for compaction.

Compact material placed in all layers to at least 95 percent of the maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

Do not apply density requirements as measured by AASHTO T 310 to material incapable of being tested or compacted to maximum values determined by AASHTO T 99. For these material, fill the voids around the rocky material in each layer with earth or other fine material. Compact each layer until there is no visible evidence of further consolidation.

208.11 Acceptance. See Table 208-1 for sampling, testing, and acceptance requirements.

Material for structural backfill and foundation fill will be evaluated under Subsections 106.02 and 106.04.

Material for grout will be evaluated under Subsections 106.02 and 106.03. Grout will be evaluated under Subsections 106.02 and 106.04.

Structure excavation and backfill work will be evaluated under Subsections 106.02 and 106.04.

Clearing and removal of obstructions will be evaluated under Sections 201 and 203.

Seal concrete will be evaluated under Section 552.

Shoring, bracing, and cofferdams will be evaluated under Section 562.

Measurement

208.12 Measure the Section 208 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring structural excavation by the cubic yard (cubic meter) in its original position; do not include the following volumes in structure excavation:

(a) Material excavated outside the vertical planes located 18 inches (450 millimeters) outside and parallel to the limits of the footings or foundations;

(b) Material included within the staked limits of the excavation (such as contiguous channel changes and ditches) for which measurement is covered under other Sections;

(c) Water or other liquid material;

(d) Material excavated before measurement of the original ground;

(e) Material re-handled, except when the contract specifically requires excavation after embankment placement; or

(f) Excavation for cofferdam seals.

When measuring foundation fill and structural backfill by the cubic yard (cubic meter) in place; measure the volume placed inside the vertical planes located 18 inches (450 millimeters) outside and parallel to the limits of the footings or foundations.

Payment

208.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 208 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for structure excavation, shoring and bracing, and cofferdams will be full compensation for excavation to a depth of 6 feet (1.8 meters) below the lowest elevation shown in the plans for each foundation structure. When the excavation exceeds 6 feet (1.8 meters), either the Contractor or the CO may request an equitable price adjustment for the depth in excess of 6 feet (1.8 meters).

Table 208-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Source								
Foundation fill[1] (704.01)	Measured and tested for conformance (106.04 & 105)	Classification	–	AASHTO M 145	1 per soil type	Source of material	Yes	Before using in work
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"
Structural backfill[1] (704.04)	"	Plasticity index	–	AASHTO R 58, T 89, & T 90	"	"	"	"
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"
Production								
Foundation fill (704.01)	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C[2]	1 per soil type	Source of material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	1 per 300 yd^3 (250 m^3)	In-place	No	Before placing next layer
Structural backfill (704.04)	"	Moisture-density	–	AASHTO T 99, Method C[2]	1 per soil type	Source of material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	2 per lift	In-place	No	Before placing next layer

(1)Not required when using Government-provided source.
(2) Minimum of 5 points per proctor.

Section 209. — STRUCTURE EXCAVATION AND BACKFILL

Description

209.01 This work consists of excavating material for the construction of structures, except those specifically designated under Section 208. This work also includes preserving channels, shoring and bracing, sealing foundations, dewatering, preparing foundations, bedding, and backfilling.

Material

209.02 Conform to the following Sections and Subsections:

Backfill material	704.03
Bedding material	704.02
Foundation fill	704.01
Lean concrete backfill	614
Structural concrete, Class S (Seal)	552
Unclassified borrow	704.06

Construction Requirements

209.03 General. Clear the area of vegetation and obstructions according to Sections 201 and 203.

Excavate trenches or foundation pits according to Subsection 208.03. Excavate to foundation grade without disturbing the trench or foundation surface. Foundation grade is the elevation at the bottom of the bedding for installing the structure.

209.04 Channel Preservation. Preserve channels according to Subsection 208.04, except excavate inside separations such as dikes or sandbags.

209.05 Foundation Seal. When foundation seals are necessary, construct a foundation seal according to Subsection 208.06.

209.06 Dewatering. When dewatering is necessary, dewater according to Subsection 208.07.

209.07 Foundation Preparation. Excavate unsuitable material when encountered at foundation grade as directed by the CO.

Where a footing is required to be keyed into undisturbed material, prepare foundation and construct footing according to Subsection 208.08(c).

Backfill and compact with foundation fill according to Subsection 208.08(d).

209.08 Bedding. Place bedding as follows:

(a) For box culverts and structures other than pipe culverts. Construct bedding when specified. Place and grade bedding material in compacted layers not exceeding 6 inches (150 millimeters) in depth. Compact each layer according to Subsection 209.10.

(b) For pipe culverts. Level the foundation. Place uncompacted bedding material over the foundation in a layer of uniform thickness. Lay a 4-inch (100-millimeter) thickness of bedding for pipes with diameters of 12 to 54 inches (300 to 1350 millimeters). Lay a 6-inch (150-millimeter) thickness of bedding for pipe with diameters larger than 54 inches (1350 millimeters). Recess the bedding to receive the joints for pipes with belled joints. Place the culvert on the uncompacted bedding layer and backfill according to Subsection 209.09(b).

209.09 Backfill. Backfill as follows:

(a) General. Place backfill layers evenly on all sides of the structure. Extend each layer to the limits of the excavation or natural ground.

Place backfill material in compacted layers not exceeding 6 inches (150 millimeters) in depth.

Do not place backfill material against concrete until 80 percent of the design strength is achieved.

Compact each layer according to Subsection 209.10.

(b) Pipe culverts. Backfill according to one of the following:

(1) Pipe culverts. Place and compact backfill material in evenly balanced layers on each side of the pipe to a height of 12 inches (300 millimeters) above the top of the pipe culvert.

Complete backfilling to the top of the trench. Place and compact backfill material in the trench in layers not exceeding 6 inches (150 millimeters) in depth according to Subsection 209.10.

(2) Pipe culverts with lean concrete backfill. Place and anchor pipe to prevent floating and movement. Backfill using lean concrete according to Section 614.

(c) Structural plate structures. Place and compact backfill material to a height of 12 inches (300 millimeters) above the top of the structural plate structure. When applicable, complete backfilling and compacting according to Subsection 204.10.

(d) Repair existing pavement areas. See Subsection 418.04.

209.10 Compacting. Determine optimum moisture content and maximum dry density according to AASHTO T 99, Method C. Adjust the moisture content of the backfill material to a moisture content suitable for compaction.

Compact material placed in all layers to at least 95 percent of the maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

Do not apply density requirements as measured by AASHTO T 310 to material incapable of being tested or compacted to maximum values determined by AASHTO T 99. For these material, fill the voids around the rock in each layer with earth or other fine material. Compact each layer until there is no visible evidence of further consolidation.

209.11 Acceptance. See Table 209-1 for sampling, testing, and acceptance requirements.

Material for backfill, bedding, and foundation fill will be evaluated under Subsections 106.02 and 106.04, except lean concrete for bedding or backfill will be evaluated according to Section 614.

Structural excavation and backfill work will be evaluated under Subsections 106.02 and 106.04.

Shoring and bracing will be evaluated under Subsections 106.02 and 106.04.

Clearing and removal of obstructions will be evaluated under Sections 201 and 203.

Seal concrete will be evaluated under Section 552.

Measurement and Payment

209.12 Do not measure structure excavation and backfill for payment. See Subsection 109.05.

Measure foundation fill under Section 208.

Do not measure excavation and concrete for cofferdam seals for payment.

Table 209-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Source								
Backfill material[1] (704.03)	Measured and tested for conformance (106.04 & 105)	Classification	–	AASHTO M 145	1 per soil type	Source of material	Yes	Before using in work
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"
Bedding material[1] (704.02)	"	"	–	"	"	"	"	"
Foundation fill[1] (704.01)	"	Classification	–	AASHTO M 145	"	"	"	"
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"
Unclassified borrow[1] (704.06)	"	Classification	–	AASHTO M 145	"	"	"	"

Table 209-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Production								
Backfill material (704.03)	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C[2]	1 per soil type	Source of material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	2 per lift	In-place	No	Before placing next layer
Bedding material (704.02)	"	Moisture-density	–	AASHTO T 99, Method C[2]	1 per soil type	Source of material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	2 per lift	In-place	No	Before placing next layer
Foundation fill (704.01)	"	Moisture-density	–	AASHTO T 99, Method C[2]	1 per soil type	Source of material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	2 per lift	In-place	No	Before placing next layer
Unclassified borrow (704.06)	"	Moisture-density	–	AASHTO T 99, Method C[2]	1 per soil type	Source of material	Yes	Before using in work
		Density	–	AASHTO T 310 or other approved procedures	2 per lift	In-place	No	Before placing next layer

(1) Not required when using Government-provided source.
(2) Minimum of 5 points per proctor.

Section 210. — RESERVED

Section 211. — ROADWAY OBLITERATION

Description

211.01 This work consists of obliterating or closing roadways and other areas outside the roadway prism.

Roadway obliteration methods are designated as follows:

(a) Method 1. Obliterate the roadway by restoring to approximate original ground contours. Keep excavated material within the original construction limits. Finish slopes to provide gradual transitions in slope adjustments without noticeable breaks.

(b) Method 2. Close roads by filling ditches and outsloping the roadbed to drain. Remove and slope embankment material at localized drainages to restore the natural drainage patterns. Eliminate ruts and low spots that could hold water.

Construction Requirements

211.02 Conform to the following when obliterating or closing roadways:

(a) Rigid material.

(1) Nonasphalt material. Break concrete pavements, curbs, gutters, sidewalks, and other nonasphalt rigid material into pieces with maximum dimension of 12 inches (300 millimeters) when burying according to Subsection 203.05(c). As an alternative to breaking and burying, remove the rigid material from the project and dispose of it according to Subsection 203.05(a).

(2) Asphalt material. Dispose of asphalt material in a manner consistent with state and local regulations. Asphalt material may be considered hazardous waste. Submit copies of the disposal permits. Where no regulations exist, dispose of the material as described in Subsection 211.02(a)(1).

(b) Nonrigid material.

(1) Nonasphalt material. Scarify or rip the gravel, crushed stone, or other nonrigid surface, base, and subbase material. Mix the scarified or ripped material with the underlying soil. Bury the mixture under at least 12 inches (300 millimeters) of soil.

(2) Asphalt contaminated material. Dispose of asphalt contaminated material according to Subsection 211.02(a)(2).

211.03 Waterbars and Barriers. Construct barriers to prevent vehicle access and waterbars as shown in the plans.

211.04 Acceptance. Roadway obliteration will be evaluated under Subsection 106.02.

Measurement

211.05 Measure the Section 211 pay items listed in the bid schedule according to Subsection 109.02.

Payment

211.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 211 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 212. — LINEAR GRADING

Description

212.01 This work consists of constructing roadbeds within the specified alignment and grade tolerances.

Construction Requirements

212.02 Roadway Preparation. Clear the area of vegetation and obstructions according to Sections 201 and 203.

212.03 Roadway Excavation and Embankment. Construct the roadbeds according to the applicable requirements of Section 204, except as modified herein.

Adjust the moisture content of embankment material to a moisture content suitable for compaction. Place embankment material in 12-inch (300-millimeter) layers and compact each layer according to Subsection 204.11(a). Where compacting with rollers is not practical, use approved mechanical or vibratory compaction equipment.

Construct approach connections to existing roads, parking areas, and trails. Construct new approaches.

212.04 Grading Tolerance. Do not encroach on stream channels, impact wetlands, or extend beyond right-of-way or easement limits. Do not make alignment or profile grade adjustments that adversely affect drainage. Construct the roadbed within the following grading tolerances:

(a) Alignment (centerline). Alignment may be shifted a maximum of 10 feet (3 meters) left or right of the planned centerline. Curve radii may be reduced by up to 50 percent. Do not construct curves with radii less than 100 feet (30 meters). Compound curves are permitted.

(b) Profile grade. Profile grade may be shifted a maximum of 5 feet (1.5 meters) up or down from the plan elevation provided the new grade tangent does not vary more than 2 percent from the plan grade tangent. Connect revised forward and back grade tangents with a uniform vertical curve consistent with the design.

212.05 Acceptance. Linear grading will be evaluated under Subsections 106.02 and 106.04.

Clearing and removal of obstructions will be evaluated under Sections 201 and 203.

Measurement

212.06 Measure the Section 212 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Do not measure changes in the clearing and grubbing quantity caused by alignment adjustments under Subsection 212.04.

Payment

212.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 212 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 213. — SUBGRADE STABILIZATION

Description

213.01 This work consists of processing and incorporating lime, lime/fly ash, or hydraulic cement into the upper layer of subgrade.

Material

213.02 Conform to the following Subsections:

Chemical admixtures	711.03
Fly ash	725.04(a)
Hydraulic cement	701.01
Lime for soil stabilization	725.03(b)
Water	725.01(c)

Construction Requirements

213.03 Proportioning. Submit a subgrade stabilization mix design at least 30 days before production. Include compressive strength values for at least three application rates with at least one application rate above and one below the strength shown in Table 213-1.

Table 213-1
Subgrade Stabilization Compressive Strength Requirements

Stabilization Mixture	Test Procedure	Average Unconfined Compressive Strength (minimum of 3 specimens)
Lime/Soil	ASTM D5102, Procedure B	100 pounds per square inch (0.70 megapascals)(1)
Lime/Fly ash/Soil	ASTM D5102, Procedure B	150 pounds per square inch (1.0 megapascals)(1)
Cement/Soil, Cement/Fly ash/Soil, or Fly ash/Soil	ASTM D1633, Method A	200 pounds per square inch (1.4 megapascals)(2)

(1) At 7-day cure at 105 °F (40 °C).
(2) At 7-day cure.

Include the following with the mix design as applicable:

(a) Source of each component material;

(b) Results of the applicable tests including optimum moisture content (after treatment), hydration moisture rate, maximum dry density (after treatment), Atterberg limits (before and after treatment), and recommended application rates of stabilizing material; and

(c) When requested by the CO:

(1) 200-pound (90-kilogram) sample of the subgrade soil;

(2) 25-pound (12-kilogram) sample of the fly ash;

(3) 25-pound (10-kilogram) sample of the lime;

(4) 25-pound (10-kilogram) sample of the cement; and

(5) 2-pound (1-kilogram) sample of each chemical admixtures.

Begin production after the mix design is approved. Furnish a new mix design if there is a material source change.

213.04 Production Start-Up Procedures. Conduct a pre-stabilization preparatory phase meeting at least 7 days before the start of stabilizing operations according to Subsection 153.04(a).

Provide at least 7 days notice before beginning production.

213.05 General. Store lime, fly ash, hydraulic cement, and chemical admixtures in closed, weatherproof containers.

Prepare the subgrade according to Subsection 303.05. Scarify or pulverize the subgrade to the required depth. Use a rotary mixer with direct water injection capabilities to adequately blend the material and to produce a homogeneous mixture within 2 percent of the optimum moisture content.

At the end of each production day, shape the subgrade surface to provide positive drainage. Provide a construction joint according to Subsection 305.11 for tying into existing stabilized subgrade.

213.06 Application. Do not apply lime, fly ash, or hydraulic cement when weather conditions cause excessive material loss or when the air temperature may fall below 32 °F (0 °C) within 48 hours. Apply material when the subgrade material temperature is at least 40 °F (5 °C).

Adjust the subgrade material moisture content to 2 to 3 percent above optimum.

Apply fly ash by the dry method. Apply lime and cement by either the dry or slurry method.

(a) Dry method. Uniformly apply the stabilizers using a metered spreader approved by the CO. A motor grader is not an approved spreader. Apply water using approved methods to obtain the proper moisture content for mixing and compaction. If quicklime and fly ash are pre-blended, limit the maximum particle size of the quicklime to ⅛ inch (3 millimeters) to avoid segregation.

(b) Slurry method. Mix material with water. Report the percent solids in the slurry to the CO for each production day. Apply the slurry using either trucks with approved distributors or rotary mixers. Equip the distributor truck or rotary mixer tank with an agitator to keep the stabilizers suspended in water. Make successive passes over the material to obtain the proper moisture and additive content.

213.07 Mixing. Keep traffic, except mixing equipment off the spread material. Use a rotary mixer.

(a) Lime mixtures.

(1) Preliminary mixing. Adjust the moisture content of the mixture to optimum plus necessary hydration moisture. Use the mix design hydration moisture rate. Thoroughly mix the lime, soil, and water to obtain a homogeneous friable mixture. Complete the mixing on the same day lime is applied. Check to ensure lime is fully hydrated and add additional water if necessary.

Mellow the mixture for 1 to 4 days at a moisture content of 2 to 3 percent above optimum as directed by the CO.

(2) Final mixing. Remix until 95 percent of the mixture, except hard and durable particles, passes a 1½-inch (37.5-millimeter) sieve and at least 50 percent of the soil portion of the mixture passes a No. 4 (4.75-millimeter) sieve when tested according to AASHTO T 27 in the non-dried condition.

(b) Lime/fly ash mixtures. Mix according to Subsection 213.07(a)(1). Use either a pre-blended lime/fly ash mixture or mix the lime and fly ash in separate operations.

If the lime and fly ash are mixed separately, mix the lime first and mix the fly ash within 2 days of lime mixing. Adjust the moisture content of the lime/fly ash mixture to 2 to 3 percent above optimum. Mix the material to prevent formation of fly ash balls. Complete the mixing within 2 hours after adding the fly ash.

(c) Cement, fly ash, or cement/fly ash mixtures. Add water to adjust the moisture content of the mixture to 2 to 3 percent above optimum. Mix the material until 95 percent of the soil portion of the mixture hard and durable particles passes a 1½-inch (37.5-millimeter) sieve and at least 50 percent of the soil portion of the mixture passes a No. 4 (4.75-millimeter) sieve when tested according to AASHTO T 27 in the non-dried condition. Complete the mixing within 2 hours after the cement, fly ash, or both are added.

213.08 Compacting and Finishing. Immediately after final mixing, spread and compact the mixture. Use a vibratory sheep-foot roller to achieve compaction. Use pneumatic-tire and smooth-drum rollers for finish rolling.

Compact the mixture to at least 95 percent of maximum dry density from the approved mix design. Complete compaction operations within 2 hours of completion of mixing.

Finish the compacted subgrade to within plus or minus 0.10 foot (30 millimeters) of the staked line, grade, and cross-section. Check the surface with a 10-foot (3-meter) straightedge.

Add or remove material to correct surface deviations in excess of ¾ inches in 10 feet (19 millimeters in 3 meters) between two contacts of the straightedge with the surface. When adding material, scarify the subgrade to at least 6 inches (150 millimeters). Recompact the area to restore the required density and strength. For Subsection 213.07(b) or (c) mixtures, complete compaction operations within 2 hours of adding the cement, fly ash, or both.

213.09 Curing. Keep the subgrade continuously moist and within 3 percent of optimum moisture content until the next course is placed. Apply water under pressure through a spray bar equipped with nozzles, which produce a fine, uniform spray. Place the next course within 14 days after compacting and finishing. If the subgrade deforms, loses density, or ravels before placement of the next course; correct the damaged subgrade.

Traffic may be allowed on the stabilized subgrade 24 hours after compaction and finishing if approved by the CO.

213.10 Acceptance. See Table 213-2 for sampling, testing, and acceptance requirements.

Material for chemical admixtures, fly ash, lime, hydraulic cement, and water will be evaluated under Subsections 106.02 and 106.03.

Subgrade stabilization work will be evaluated under Subsections 106.02 and 106.04.

Reconditioning of subgrade will be evaluated under Section 303.

Measurement

213.11 Measure the Section 213 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure width horizontally to include the top of subgrade width and allowable widening. Measure length horizontally along the centerline of the roadway.

Payment

213.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 213 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 213-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Mix Design								
Subgrade stabilization	Measured and tested for conformance (106.04)	Proportioning	–	Subsection 213.03	1 per submitted mix design	Existing roadbed / subgrade	Yes	30 days before production
Production								
Stabilized material	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C(1)	1 per soil type, but not less than 1 for each day of production	Processed material behind mixer	Yes, when requested	Before using in work
		Gradation	–	AASHTO T 27 & T 11	1 per 3500 yd^2 (3000 m^2), but not less than 1 per layer	"	"	"
		Density	–	AASHTO T 310 or other approved procedures	"	In-place	No	Before placing next layer
		Compressive strength (7-day cure)	–	ASTM D5102(2), D1633(3) as applicable	"	Processed material behind mixer	Yes, when requested	"

(1) Minimum of 5 points per proctor.

(2) At 7-day cure at 105°F (40 °C). Compact sampled material immediately according to Procedure B. Do not complete the proportioning and mixing of Sections 10.2 and 10.3. Report average unconfined compressive strength from at least three specimens.

(3) At 7-day cure. Report average unconfined compressive strength from at least three specimens.

DIVISION 250
SLOPE REINFORCEMENT AND RETAINING WALLS

Section 251. — RIPRAP

Description

251.01 This work consists of furnishing and placing riprap for bank protection, slope protection, drainage structures, and erosion control.

Riprap acceptance methods are designated according to Table 251-1. If no acceptance method is designated, use Method A.

Riprap classes are designated according to Table 705-1.

Geotextile filters are designated according to Table 714-1.

Material

251.02 Conform to the following Subsections:

Geotextile	714.01
Neat hydraulic cement grout	725.13(a)(2)
Riprap	705.02

Construction Requirements

251.03 General. Perform the work under Section 209. Dress the slope to produce a smooth surface. If geotextile filter is required, place according to Section 207.

251.04 Placed Riprap. Placed riprap is rock placed on a prepared surface to form a well-graded mass.

Place riprap to its full thickness in one operation to avoid displacing the underlying material. Do not place riprap material by methods that cause segregation or damage to the prepared surface. Place or rearrange individual rocks by mechanical or hand methods to obtain a dense uniform blanket with a reasonably smooth surface.

251.05 Keyed Riprap. Keyed riprap is rock placed on a prepared surface and set into place by impact pressure.

Place rock for keyed riprap according to Subsection 251.04. Set the riprap into place by exerting impact pressure with a hydraulic-powered bucket or an approximate 5000-pound (2000-kilogram) flat-faced mass. Repeated impacts should be made until the rock is firmly seated and forms a reasonably uniform surface without reducing the effective sizes of the rocks. Do not use impact pressure on riprap below the water surface.

251.06 Grouted Riprap. Grouted riprap is rock placed or keyed on a prepared surface with the voids filled with grout.

Place rock for grouted riprap according to Subsection 251.04 or 251.05. Thoroughly moisten the rocks and wash excess fines from the riprap or to the underside of the riprap. Do not place grout unless the air temperature is at or above 35 °F (1 °C) within the near-surface voids of the riprap. Place the grout in a manner to prevent segregation. Begin placing grout at the lowest elevation of the riprap. Fill voids without unseating the rocks. Do not exceed 5-foot (1.5-meter) thickness for each layer of grouted riprap. Allow 3 days curing time before adding the next layer of riprap and grout. Provide weep holes through the grouted riprap as required. Keep the grouted riprap moist for 3 days after the work is completed and protect it from freezing for at least 7 days after grouting.

251.07 Acceptance. See Table 251-1 for sampling, testing, and acceptance requirements.

Rock for riprap will be evaluated under Subsections 106.02 and 106.04.

Material for grout will be evaluated under Subsections 106.02 and 106.03.

Acceptance Method A riprap construction will be evaluated under Subsection 106.02.

Acceptance Method B riprap construction will be evaluated under Subsections 106.02 and 106.04.

Placing grout will be evaluated under Subsection 106.02.

Geotextile filters will be evaluated under Section 207.

Structure excavation and backfill will be evaluated under Section 209.

Measurement

251.08 Measure the Section 251 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring riprap by the cubic yard (cubic meter), measure in place.

Payment

251.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 251 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 251-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Riprap (705.02)	Measured and tested for conformance (106.04 & 105)	Apparent specific gravity & absorption	–	AASHTO T 85	1 per material type	Source of material	Yes	Before using in work	–
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	–
		LA abrasion	–	AASHTO T 96	"	"	"	"	–
Production									
Riprap (705.02)	Process control (153.03)	Size Methods A & B	–	See Note (2)	1 per 100 yd^3 (80 m^3) per Class	In-place	"	"	–
	Measured and tested for conformance (106.02 & 106.04)	Gradation(1) Method B	–	FLH T 521	1 per 1000 yd^3 (800 m^3) per Class	Stockpile or in-place(3)	No	24 hours	–

(1) Notify CO at least 7 days before performing test.

(2) Verify riprap class by confirming that the largest accessible rock has an intermediate dimension greater than the upper limit of the D85 size range specified in Table 705-1.

(3) Point of sampling to be approved by CO.

Section 252. — ROCKERY, SPECIAL ROCK EMBANKMENT, AND ROCK BUTTRESS

Description

252.01 This work consists of constructing rockeries, special rock embankments, and rock buttresses.

Geotextile filters are designated according to Table 714-1.

Material

252.02 Conform to the following Subsections:

Foundation fill	704.01
Geotextile	714.01
Granular rock backdrain	703.17
Neat hydraulic cement grout	725.13(a)(2)
Rock for buttresses	705.05
Rock for rockeries	705.06
Rock for special rock embankment	705.04

Construction Requirements

252.03 Rockery. Verify the limits of the rockeries. Notify the CO if planned rockery lengths, heights, or both are inadequate to intersect with adjacent slopes. Submit cross-sections verifying intersections for approval.

Construct rockeries as follows:

(a) Excavation. Perform the work under Sections 204 and 209 as required. Do not excavate more areas for rockeries than can be replaced with rockery construction in one shift unless shoring is provided. Protect backslopes from damage by surface water.

(b) Erection. Remove sharp objects from the backslope before installing geotextile filter. Anchor geotextile filter to the excavation backslope to withstand backfilling operations. Overlap the geotextile filter at least 24 inches (600 millimeters) at seams. Reinforce damaged fabric with a patch of the same type of geotextile filter by overlapping the patch 36 inches (900 millimeters) beyond the damaged area in all directions.

Furnish and install drain systems according to Section 605 when specified. Do not connect collector pipes to storm water retention systems unless approved by the CO.

Seat rocks firmly on a prepared foundation.

Place rocks to avoid continuous joints in either the vertical or horizontal direction. Locate at least one bearing point a distance no greater than 6 inches (150 millimeters) from the face of the rockery. Place each rock to ensure it bears on at least two rocks below. Place incrementally smaller rocks as construction proceeds in successive lifts. Slope the top surface of each rock towards the back of the rockery at an inclination of at least 5 percent.

Choke voids from the drain side of the rockery in each successive lift. Choke voids greater than 6 inches (150 millimeters) with a rock large enough to fill the void.

Backfill with granular rock backdrain concurrent with rock placement until level with the top of rock. Place granular rock backdrain in horizontal layers not to exceed 12 inches (300 millimeters) compacted depth. Compact each layer according to Subsection 204.11. Compact areas not accessible to rollers with other approved methods.

252.04 Special Rock Embankment and Rock Buttress. Verify the limits of embankments and buttresses. Notify the CO if the embankment or buttress lengths, heights, or both are inadequate to intersect with adjacent slopes. Perform the work under Sections 204 or 209 as required. When specified, place geotextile filter according to Section 207.

Place rocks in a stable orientation with minimal voids to produce a random pattern. Construct the exposed face of the rock mass reasonably uniform with projections beyond the line of the slope that are no greater than 12 inches (300 millimeters) for mechanically-placed rock or 6 inches (150 millimeters) for hand-placed rock.

Use rock smaller than the minimum rock size to choke the larger rock solidly in position and to fill voids between the large rocks.

252.05 Acceptance. See Table 252-1 for sampling, testing, and acceptance requirements.

Material for rockeries, special rock embankments, and rock buttresses will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of rockeries, special rock embankments, and rock buttresses will be evaluated under Subsections 106.02 and 106.04.

Roadway excavation will be evaluated under Section 204.

Geotextile filters will be evaluated under Section 207.

Structure excavation and backfill will be evaluated under Section 209.

Measurement

252.06 Measure the Section 252 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring rockeries by the square feet (square meter) of rockery front face; measure the rockery from the bottom of the base rock elevation to the top of the cap rock elevation. Measure front face on a plane parallel to the rockery face.

When measuring special rock embankment and rock buttress by the cubic yard (cubic meter), measure in place.

Payment

252.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 252 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 252-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Rock for buttresses (705.05)	Measured and tested for conformance (106.04 & 105)	Rock breadth and thickness	–	Subsection 705.05(a)(1)	1 per rock type	Source of material	No	Before using in work	–
		Apparent specific gravity	–	AASHTO T 85	"	"	Yes	"	Not required when using Government -provided source
		Absorption	–	"	"	"	"	"	"
		Durability index (course)	–	AASHTO T 210	"	"	"	"	"
Rock for rockeries (705.06)	"	Apparent specific gravity	–	"	1 per rock type	Source of material	Yes	Before using in work	Not required when using Government -provided source
		Absorption	–	"	"	"	"	"	"
		LA abrasion	–	AASHTO T 96	"	"	"	"	"
		Durability index (course)	–	AASHTO T 210	"	"	"	"	"
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	"

Table 252-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Rock for special rock embankment (705.04)	Process control (153.03)	Size	–	See Note (1)	1 per 100 yd^3 (80 m^3)	In-place	No	24 hours	–
Rock for buttresses (705.05)	"	"	–	"	1 per 100 yd^3 (80 m^3)	"	"	"	–
Rock for rockeries (705.06)	"	"	–	See Note (2)	2 per lift of rock per rockery	"	"	"	–

(1) For mechanically placed embankments, verify rock size by confirming that the largest accessible rock has an intermediate dimension greater than the D50 size specified in Table 705-2. Also confirm that the smallest accessible rock has an intermediate dimension within the lower D50 size range specified in Table 705-2.

For hand placed embankments, verify rock size by confirming that the largest accessible rock has an intermediate dimension greater than the D75 size specified in Table 705-3. Also confirm that the smallest accessible rock has an intermediate dimension within the D25 size range specified in Table 705-3.

(2) Verify rock size by confirming that the largest accessible rock has a width greater than the minimum width specified in the Rockery Design Table and Rockery Detail Sheets in the plans.

Section 253. — GABIONS AND REVET MATTRESSES

Description

253.01 This work consists of constructing rock filled gabion structures and revet mattresses.

(a) Gabions baskets. A rock filled wire enclosure having a height of 12 inches (300 millimeters) or more.

(b) Revet mattresses. A rock filled wire enclosure having a thickness of less than 12 inches (300 millimeters).

Geotextile filters are designated according to Table 714-1.

Material

253.02 Conform to the following Subsections:

Backfill material	704.03
Gabion and revet mattress material	720.02
Gabion and revet mattress rock	705.01
Geotextile	714.01
Structural backfill	704.04

Construction Requirements

253.03 General. Verify the limits of the structure. Submit drawings according to Subsection 104.03. See Section 257 for Contractor-designed gabion walls.

Perform excavation and backfill according to Section 209.

253.04 Basket Assembly. Furnish twisted wire or welded wire baskets. Do not damage wire coatings during basket assembly, structure erection, cell filling, or backfilling. Rotate the basket panels into position and join the vertical edges with fasteners according to Subsection 253.05. Temporary fasteners may be used for basket assembly if they are supplemented during structure erection with permanent fasteners according to Subsection 253.05.

Rotate the diaphragms into position and join the vertical edges according to Subsection 253.05.

253.05 Structure Erection. Place the empty gabion baskets on the foundation and interconnect the adjacent baskets along the top and vertical edges using permanent fasteners.

Where lacing wire is used, wrap the wire with alternating single and double loops every other mesh opening and not more than 6 inches (150 millimeters) apart. Where spiral binders are used, crimp the ends to secure the binders in place. Where alternate fasteners are used, space the fasteners in every mesh opening and not more than 6 inches (150 millimeters) apart.

Interconnect each vertical layer of baskets to the underlying layer of baskets along the front, back, and sides. Stagger the vertical joints between baskets of adjacent rows and layers by at least one-half the cell length.

253.06 Cell Filling. Remove kinks and folds in the wire mesh, and properly align the baskets. Place rock carefully in the basket cells to prevent bulging of the baskets and to minimize voids in the rock fill. Maintain the basket alignment.

Place stiffeners in each unrestrained exterior basket cell greater than 12 inches (300 millimeters) in height. This includes interior basket cells left temporarily unrestrained. Place stiffeners concurrently with rock placement.

Fill the cells in a row or layer to ensure no cell is filled more than 12 inches (300 millimeters) above an adjacent cell. Repeat this process until the basket is full and the lid bears on the final rock layer.

Secure the lid to the sides, ends, and diaphragms according to Subsection 253.05. Make exposed basket surfaces smooth and neat with no sharp rock edges projecting through the wire mesh.

253.07 Backfilling. Place a geotextile filter over the back face of the gabion structure. Concurrently with the cell filling operation, backfill the area behind the gabion structure with structural backfill according to Subsection 209.09. Compact each layer according to Subsection 209.10, except use an acceptable lightweight mechanical or vibratory compactor within 36 inches (900 millimeters) of the gabion structure.

253.08 Revet Mattresses. Place a geotextile filter according to Section 207. Construct revet mattresses according to Subsections 253.04 through 253.06. Anchor the mattresses in place according to the manufacturer's recommendations. Place geotextile filter against the vertical edges of the mattress and backfill against the geotextile filter using backfill material. Overfill revet mattresses by 1 to 2 inches (25 to 50 millimeters).

253.09 Acceptance. See Table 209-1 for sampling, testing, and acceptance requirements.

Material for gabion structures and revet mattresses will be evaluated under Subsections 106.02 and 106.03.

Construction of gabion structures and revet mattresses will be evaluated under Subsections 106.02 and 106.04.

Geotextile filters will be evaluated under Section 207.

Structure excavation, structural backfill, and backfill material will be evaluated under Section 209.

Measurement

253.10 Measure the Section 253 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring gabions by the cubic yard (cubic meter), measure in the structure.

Measure foundation fill under Section 208.

Payment

253.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 253 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 254. — RESERVED

Section 255. — MECHANICALLY-STABLILIZED EARTH WALLS

Description

255.01 This work consists of constructing mechanically-stabilized earth (MSE) walls.

Geotextile filters are designated according to Table 714-1.

Reinforcement geotextile and geogrid are designated according to Tables 714-5 and 714-6.

Material

255.02 Conform to the following Section and Subsections:

Concrete masonry units	725.07(a)
Geotextile	714.01
Mechanically-stabilized earth wall material	720.01
Minor concrete	601
Reinforcement geotextile and geogrid	714.04
Select granular backfill	704.08
Unclassified borrow	704.06

Construction Requirements

255.03 General. Verify limits of the wall installation. Submit installation drawings according to Subsection 104.03. See Section 257 for Contractor-designed MSE walls.

Perform the work under Section 209. Grade the foundation for a width equal to the length of reinforcing elements plus the additional width shown in the plans.

When required, as determined by the Contractor, design and construct temporary shoring with consideration of maintenance of traffic requirements in Section 156. See Section 208 for temporary shoring.

For concrete panel and block-faced walls, provide a precast reinforced or a non-reinforced cast-in-place concrete leveling pad. Cure cast-in-place leveling pads at least 12 hours before placing wall panels.

255.04 Wall Erection. Erect the wall according to the drawings and manufacturer’s recommendations. Have an field representative from the wall system manufacturer on site during the startup of wall erection. Construct MSE walls to the tolerance requirements of Table 255-1.

Table 255-1
Construction Tolerance

Facing Type	Vertical Tolerance[1]	Horizontal Tolerance[2]	Horizontal Straight Edge Point Check[3]
Precast concrete panel, masonry block units	±0.6 inch (±15 mm)	±0.6 inch (±15 mm)	±0.6 inch (±15 mm)
Welded wire, gabions	±1½ inch (±38 mm)	±1½ inch (±38 mm)	±3 inch (±75 mm)

(1) Wall vertical tolerance at top of wall for every 10 feet (3 meters) of wall height. For example 65 feet (20 meter) wall height multiply 6.5×value.

(2) Wall horizontal tolerance at top of wall for every 10 feet (3 meters) of wall height.

(3) Maximum horizontal deviation at a point in the wall from a 10-foot (3-meter) straightedge placed horizontally or vertically on the theoretical plane of the design face.

(a) Precast concrete panel-faced. Erect panels by lifting devices connected to the upper edge of the panel.

Make the joint openings ¾±¼ inch (19±6 millimeters) wide. Install joint material according to the drawings. Cover joints on the backside of the panels with a 12-inch (300-millimeter) wide strip of geotextile filter. Overlap geotextile filter splices at least 4 inches (100 millimeters).

Hold the panels in position with temporary wedges or bracing during backfilling operations.

(b) Wire-faced. Place backing mats in successive horizontal lifts as backfill placement proceeds. Connect, tighten, and anchor soil reinforcement elements to the wall facing units before placing backfill. Do not place reinforcing elements below the corresponding connection elevations. Pull and anchor the reinforcement mesh taut before placing additional backfill. Do not use hardware cloth or geosynthetic material to retain backfill at the face of the wall.

(c) Gabion-faced. Place the first lift of backfill before filling the gabion baskets. Construct gabion structures according to Section 253. Lay reinforcement mesh horizontally on compacted fill and normal to the face of the wall. Connect the gabion facing unit to reinforcement mesh with spiral binders or tie wire at 4-inch (100-millimeter) nominal spacing with alternating single and double locked loops. Pull and anchor the reinforcement mesh taut before placing additional backfill.

(d) Concrete masonry block-faced. Place the first course of modular block wall units on top of and in full contact with the leveling pad. Place units side by side for the full length of the wall such that adjoining blocks are located according to the manufacturer's recommendations. Place units to ensure only the front face of the unit is visible. Check for proper elevation and alignment every two courses. Install connection devices, alignment devices, or both as required by design. Fill voids in and around units with unit fill as required by manufacturer's installation guidelines to meet the required connection strength. Place geotextile filter between unit fill and select granular backfill. If the unit fill is required to meet connection strength specifications, completely fill each course of block before proceeding to the next course. Place reinforcement no more than two times the block depth or 24 inches (600 millimeters), whichever is less. Remove excess material from the top of the units before installing each succeeding block course.

255.05 Backfilling. Backfill the stabilized volume with select granular backfill according to Subsection 209.09. Place select granular backfill material from the back of the wall face to the end of the reinforcement. Ensure that no voids exist below the reinforcement. Compact each layer according to Subsection 209.10, except use an acceptable lightweight mechanical or vibratory compactor within 36 inches (900 millimeters) of the wall face. Consolidate facing backfill by rodding or other approved means to produce a uniform, tight facing fill. Where the stabilized volume supports spread footings for bridges or other structural loads, compact the top 5 feet (1.5 meters) to at least 100 percent of the maximum density.

Do not damage or disturb the facing or reinforcing elements. Do not operate equipment directly on top of the reinforcing mesh or strips. Correct damaged, misaligned, or distorted wall elements.

Backfill and compact behind the stabilized volume with unclassified borrow according to Subsections 209.09 and 209.10. At the end of the day's operation, slope the last lift of backfill away from the wall face to direct surface runoff away from the wall. Do not allow surface runoff from adjacent areas to enter the wall construction area.

255.06 Acceptance. See Table 255-2 for sampling, testing, and acceptance requirements.

Material for mechanically-stabilized earth walls listed under Subsection 720.01 will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of concrete face panels.

Construction of mechanically-stabilized earth walls will be evaluated under Subsections 106.02 and 106.04.

Geotextile filters and reinforcement geotextile and geogrid will be evaluated under Section 207.

Structure excavation, select granular backfill, and unclassified borrow will be evaluated under Section 209.

Gabions will be evaluated under Section 253.

Concrete leveling pad will be evaluated under Section 601.

Measurement

255.07 Measure the Section 255 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring mechanically-stabilized earth walls by the square foot (square meter), measure the front face of wall excluding footings.

When measuring select granular backfill within the stabilized volume by the cubic yard (cubic meter), measure in place.

Measure foundation fill under Section 208.

Payment

255.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 255 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 255-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Select granular backfill (704.08)	Measured and tested for conformance (106.04 & 105)	Gradation	–	AASHTO T 27 & T 11	1 per soil type	Source of material	Yes	Before using in work	Not required when using Government-provided source
		Angle of internal friction	–	AASHTO T 236 and Subsection 704.08(a)(2)	"	"	"	"	"
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	"
		Plasticity index	–	AASHTO R 58, T 89, & T 90	"	"	"	"	"
		Resistivity[(1)]	–	AASHTO T 288	"	"	"	"	"
		pH[(1)(2)]	–	AASHTO T 289	"	"	"	"	"
		Sulfate content[(1)(3)]	–	AASHTO T 290	"	"	"	"	"
		Chloride content[(1)(3)]	–	AASHTO T 291	"	"	"	"	"

Table 255-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Select granular backfill (704.08)	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C[4]	1 per soil type	Source of material	Yes	Before using in work	–
		Density	–	AASHTO T 310 or other approved procedures	2 per lift	In-place	No	Before placing next layer	–

(1) Required for MSE walls with metallic reinforcements.

(2) Required for MSE walls with geosynthetic reinforcements.

(3) Tests for sulfate and chloride content are not required when resistivity is greater than 5000 ohm centimeters.

(4) Minimum of 5 points per proctor.

Section 256. — PERMANENT GROUND ANCHORS

Description

256.01 This work consists of furnishing and installing permanent ground anchors.

Material

256.02 Conform to the following Subsections:

Anchor tendons	722.02
Neat hydraulic cement grout	725.13(a)(1)

Construction Requirements

256.03 Qualifications. Provide a professional engineer, on-site supervisor, and installation personnel with experience installing and testing permanent ground anchors. Submit the following for approval at least 30 days before starting work:

(a) Names of personnel; and

(b) A résumé for each individual describing their experience on at least five ground anchor projects of similar complexity over the past 5 years. Include project names, locations, and contact information for project owners.

256.04 Submittal. At least 30 days before starting ground anchor work, submit the following according to Subsection 104.03:

(a) Start date;

(b) Method of excavation to ensure slope stability;

(c) Ground anchor construction sequence;

(d) Ground anchor types, sizes, spacings, depths, installation angles, bond zone lengths, and ultimate tendon strengths for the range of material to be encountered;

(e) Tendons, couplers, bearing plates, facing items, and additional hardware with manufacturer's MSDS and product data sheets, specifications, catalog cuts, and mill certificates;

(f) Manufacturer recommendations for tendon and hardware handling, storing, assembly, and working temperature ranges;

(g) Grout type, mix design, mixing equipment, placement procedures, and 7-day grout compressive strength test results;

(h) Procedures and material for repairing corrosion protection coatings in the field;

(i) Drilling methods and equipment;

(j) Drill hole diameters to achieve the specified pullout resistance;

(k) Alternative drilling and grouting methods such as grout additives;

(l) Additional material needed to achieve required bond capacities such as grout socks;

(m) Methods to ensure borehole stability during excavation and grout placement;

(n) Ground anchor testing methods and equipment including type and capacity of reaction load system, drawings, supporting calculations for structural components of the ground anchor load test apparatus, and calculations for soil bearing and settlement below the reaction frame; and

(o) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

Allow 10 days for submittal review.

256.05 Tendon Fabrication.

(a) General. Size tendons to ensure:

(1) The design load does not exceed 60 percent of the minimum ultimate tensile strength of the tendon; and

(2) The maximum test load does not exceed 80 percent of the minimum ultimate tensile strength of the tendon.

(b) Bond length. Determine the bond length necessary to develop the design load shown in the drawings. Use a minimum bond length of 10 feet (3 meters) in rock and 15 feet (4.5 meters) in soil. Provide corrosion protection of the tendon bond length with a cement grout cover.

Where encapsulation of the tendon is required, protect the tendon bond length from corrosion by encapsulating it in a grout-filled corrugated plastic or deformed steel tube or by coating it with fusion-bonded epoxy. Place the grout inside the tube either before or after the tendon is placed in the drill hole. Centralize the tendon within the tube with a minimum ⅛-inch (3-millimeter) grout cover.

(c) Centralizers. Use spacers along the tendon bond length of a multi-element tendon to separate each of the individual elements of the tendon. Use centralizers to ensure at least ½ inch (13 millimeters) of grout cover over the tendon bond length or tendon bond length encapsulation as appropriate. Use centralizers that do not impede the free flow of grout up the bore hole. Position centralizers within 5 feet (1.5 meters) from the top of the tendon bond length, within 12 inches (300 millimeters) from the bottom of the tendon bond length, and so their center-to-center spacing does not exceed 10 feet (3 meters).

Centralizers are not required on hollow-stem-augured tendons if the ground anchor is grouted through the auger and the hole is maintained full of a stiff grout during extraction of the auger. A grout is considered "s*tiff*" if its slump is less than 9 inches (230 millimeters).

(d) Unbonded length. Provide minimum unbonded length of 10 feet (3 meters) for steel bars and 15 feet (4.5 meters) for steel strands.

(1) If the entire drill hole is grouted in one operation, provide corrosion protection of the unbonded length with a sheath completely filled with corrosion-inhibiting grease, corrosion-inhibiting grout, or a heat-shrinkable tube internally coated with an elastic adhesive.

If grease is used under the sheath, completely coat the unbonded tendon length, fill spaces between individual elements of multi-element tendon with grease, and provide measures to prevent grease from escaping at the ends of the sheath.

If the sheath is grout filled, provide a separate bond-breaker along the unbonded length of the tendon.

(2) If a grease-filled sheath corrosion protection is provided and the drill hole above the bond length is grouted after the ground anchor is locked off, grout the tendon inside a second sheath.

Where restressable ground anchors are used, provide restressable anchorage compatible with the post-tensioning system provided.

If multi-element tendons are used, properly seat the wedges as recommended by the manufacturer for the post-tensioning system provided.

(e) Bearing plates. Size the bearing plates to ensure:

(1) The bending stresses in the plate do not exceed the yield strength of the steel when a load equal to 95 percent of the minimum specified ultimate tensile strength of the tendon is applied; and

(2) The average bearing stress of the bearing plate does not exceed that recommended in the PTI, *Guide Specification for Post-Tensioning Materials*.

Weld trumpet to bearing plate. Make the inside diameter of the trumpet equal to or larger than the hole in the bearing plate. Make the trumpet long enough to accommodate movements during stressing and testing. For multiple or single element tendons with encapsulation over the unbounded length, make the trumpet at least 24 inches (600 millimeters) beyond the structural fascia and soil backslope interface to allow a transition from the unbounded length to the anchorhead without damaging encapsulation. Fill the trumpet of restressable ground anchors with corrosion-inhibiting grease. Provide a permanent Buna-N synthetic rubber seal or an approved equal between the trumpet and the unbonded length corrosion protection.

Fill the trumpets of non-restressable ground anchors with grout. Provide a 12-inch (300-millimeter) minimum tightly-fitting temporary seal between the trumpet and the unbonded length corrosion protection.

256.06 Handling and Storing Material. Handle and store tendons in a manner to avoid damage or corrosion. Replace tendons exhibiting abrasions, cuts, welds, weld splatter, corrosion, or pitting. Repair or replace tendons exhibiting damage to encapsulation or sheathing. Degrease the bond length of tendons and remove solvent residue before installation.

256.07 Installation.

(a) Drilling. Drill ground anchor holes within 12 inches (300 millimeters) of the required location. Drill the longitudinal axis of the drill hole parallel to the longitudinal axis of the tendon. Install the ground anchor within three degrees of the required inclination from horizontal. Install the ground anchor with a horizontal angle within three degrees of a line drawn perpendicular to the plane of the structure. Do not extend ground anchors beyond the right-of-way or easement limits.

Insert the tendon in the drill hole to the required depth without driving or forcing. Where the tendon cannot be completely inserted, remove the tendon, and clean or redrill the hole to permit insertion.

(b) Grouting.

(1) Equipment. Use a positive displacement grout pump equipped with a pressure gage capable of measuring pressures of at least 150 pounds per square inch (1 megapascal) or twice the required grout pressure, whichever is greater. Provide a secondary pressure capability of at least 1,000 pounds per square inch (7 megapascal) to clean out grout or dirt blockages in hoses, tremie tubes, or casings. Use a high speed, high shear grout mixer with a minimum operating speed of 1,500 revolutions per minute to produce a well-mixed grout that is free of lumps or other indications of prior cement hydration. Furnish holding tanks with a variable speed high-efficiency paddle that maintains a thoroughly mixed grout for pumping.

(2) Procedures. Grout tendons into drill holes using a neat hydraulic cement grout placed in one continuous operation. Inject the grout from the lowest point of the drill hole. The grout may be placed either before or after insertion of the tendon. Record the quantity of the grout and the grout pressure for each ground anchor. Control the grout pressures to avoid excessive heaving or fracturing.

Except as indicated below, the grout above the top of the bond length may be placed at the same time as the bond length grout, but do not placed it under pressure. Do not place grout at the top of the drill hole in contact with the back of the structure or the bottom of the trumpet.

If the ground anchor is installed in a fine-grained soil using drill holes larger than 6 inches (150 millimeters) in diameter, place the grout above the top of the bond length after the ground anchor has been tested and stressed. The entire drill hole may be grouted at one time if it can be demonstrated that the ground anchor does not derive a significant portion of its load-carrying capacity from the soil above the bond length.

Use pressure grouting for grout protected tendons anchored in rock. After sealing the drill hole, pressure inject grout until a 50-pound per square inch (0.3-megapascal) grout pressure at the top of the drill hole is maintained for 5 minutes.

(c) Finishing. After grouting is complete, fill the grout tube with grout if it will remain in the hole. Wait at least 3 days before loading the tendon.

Extend the corrosion protection surrounding the unbonded length up beyond the bottom seal of the trumpet or 12 inches (300 millimeters) into the trumpet if no trumpet seal is provided.

Trim the corrosion protection surrounding the tendon so it does not contact the bearing plate of the anchorhead during testing and stressing.

Place the bearing plate and anchorhead so the axis of the tendon is within three degrees of perpendicular to the bearing plate and the axis of the tendon passes through the center of the bearing plate without bending the tendon.

If grout protected tendons or fusion-bonded epoxy encapsulations are used, electronically isolate the bearing plate, anchorhead, and trumpet from the surrounding concrete, soldier pile, or metallic element embedded in the structure.

Place trumpet grease during construction. Place trumpet grout after the ground anchor has been tested and stressed.

Completely cover anchorages permanently exposed to the atmosphere with a corrosion-inhibiting grease or grout.

Inspect the trumpet and anchorage grout levels 24 hours after initial grout placement. If needed, refill the trumpet or anchorage with grout.

256.08 Testing and Stressing.

(a) Testing equipment. Conform to the following:

(1) Dial gauges. Use two dial gauges capable of measuring to 0.001 inch (0.025 millimeters) and with sufficient travel to measure the theoretical elastic elongation of the total length at the maximum test load without resetting, accounting for elongation in both the bonded and unbonded zones. Align the gauges parallel to the axis of the anchor or pile and support the gauges independently from the hydraulic jack, ground anchor, or reaction frame.

(2) Hydraulic jack, pressure gauge and load cell. Apply test loads with a hydraulic jack and measure with a calibrated pressure gauge and electronic load cell. Use a hydraulic jack and pressure gauge with a pressure range not exceeding twice the anticipated maximum test pressure and calibrated as a unit by an independent firm within 45 days of the start of work. Use a pressure gauge graduated in 100-pound per square inch (1-megapascal) increments or less. Use a jack with ram travel sufficient to allow testing without resetting.

(3) Reference gauge. Have the reference gauge calibrated with the test jack and pressure gauge. Keep the reference gauge at the project site.

(4) Reaction frame. Provide a reaction frame designed by a professional engineer to meet the requirements of the site, resist the maximum test loads and prevent excessive deformation of the bearing surface.

(b) Stressing. Place testing equipment over the ground anchor tendon to ensure the jack, bearing plates, load cells, and stressing assembly are axially aligned with the tendon and the tendon is centered within the equipment. Do not apply loads greater than 80 percent of the minimum ultimate tensile strength of the tendon.

Place the reference pressure gauge in series with the pressure gauge, jack, and load cell so they need not be unloaded and repositioned during a test. Raise the load from one increment to another. Hold the load just long enough to measure and record the ground anchor movement to the nearest 0.001 inch (0.025 millimeters) with respect to an independent fixed reference point. Repump the jack as necessary to maintain a constant load. Monitor the load with a pressure gauge. If the load measured by the pressure gauge and the load measured by the reference pressure gauge differ by more than 10 percent, recalibrate the jack, pressure gauge, and reference pressure gauge.

(1) Performance tests. The CO will designate locations for sacrificial ground anchors for performance tests. Test according to Tables 256-1 and 256-3.

Table 256-1
Performance Test Load Sequence

Test Sequence	Test Load Increment							
	AL	0.25D	0.50D	0.75D	1.00D	1.20D	1.33D (Load-Hold Test)	Reduce to Lock-Off Load
1	•	•						
2	•	•	•					
3	•	•	•	•				
4	•	•	•	•	•			
5	•	•	•	•	•	•		
6	•	•	•	•	•	•	10 minutes*	•

AL = Alignment load (no greater than 5 percent of D (0.05D) applied to the ground anchor before setting the movement recording devices. Zero dial gauges after the first setting of A).

D = Design load.

* Hold the load to within 2 percent and measure and record the ground anchor movement during the load-hold test at 1, 2, 3, 4, 5, 6, and 10 minutes. When the ground anchor movement between 1 minute and 10 minutes exceeds 0.04 inches (1 millimeter), maintain the maximum test load an additional 50 minutes and record the movement at 20, 30, 40, 50, and 60 minutes.

(2) Proof tests. Test according to Tables 256-2 and 256-3.

Table 256-2
Proof Test Load Sequence

Test Load Increment							
AL	0.25D	0.50D	0.75D	1.00D	1.20D	1.33D (Load-Hold Test)	Reduce to Lock-Off Load
•	•	•	•	•	•	10 minutes*	•

AL = Alignment load. See alignment load note in Table 256-1.

D = Design load.

* Hold the load to within 2 percent and measure and record the ground anchor movement during the load-hold test at 1, 2, 3, 4, 5, 6, and 10 minutes. When the ground anchor movement between 1 minute and 10 minutes exceeds 0.04 inches (1 millimeter), maintain the maximum test load an additional 50 minutes, recording movement at 20, 30, 40, 50, and 60 minutes.

(c) Lock off. Reduce the load to the specified lock-off load and transfer the load to the anchorage device. After transferring the load and before removing the jack, measure the lift-off load. If the load is not within 10 percent of the specified lock-off load, reset the anchorage and remeasure the lift-off load. Repeat as necessary.

256.09 Test Results and Reporting. Plot the ground anchor movement versus the maximum load for each test sequence in Tables 256-1 and 256-2, and plot the residual movement of the tendon at each alignment load versus the highest previously applied load.

Provide preliminary results to the CO for each ground anchor tested before testing personnel leave the site. Submit detailed verification and proof test load and deflection data in a tabular format. Submit a graph that plots total ground anchor head movement versus load, the A-line, and the B-line. The A-line is defined as 0.8 multiplied by the theoretical free test length elastic elongation. The B-line is defined as the theoretical free test length elastic elongation plus 0.50 multiplied by the theoretical bonded length elastic elongation. Allow 5 days for the CO to conduct a review of the data and approve ground anchor installation.

256.10 Acceptance. See Table 256-3 for sampling, testing, and acceptance requirements.

Material for ground anchors will be evaluated under Subsections 106.02 and 106.03. Submit a production certification for the ground anchor material.

Construction of ground anchors will be evaluated under Subsections 106.02 and 106.04.

Installed ground anchors will be evaluated based on one of the following performance or proof test results:

(a) After a 10-minute hold, the ground anchor carries the maximum test load with less than 0.04 inches (1 millimeter) of movement between 1 and 10 minutes and the total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

(b) After a 60-minute hold, which is only conducted after 10-minute hold test fails, the ground anchor carries the maximum test load with a movement rate that does not exceed 0.08 inch (2 millimeters) per log cycle of time and the total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

Replace ground anchors with unacceptable performance or proof test results. Do not retest failed ground anchors.

Measurement

256.11 Measure the Section 256 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure performance tests that indicate acceptable installations.

Payment

256.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 256 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 256-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (fine) (703.01)	Measured and tested for conformance (106.04 & 105)	Quality	–	AASHTO M 6	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Neat hydraulic cement grout [(1)] (725.13(a)(1))	Measured and tested for conformance (106.04)	Flow	–	ASTM C939	1 per mix design	"	Yes, when requested	"	–
		Compressive strength (7-day)	–	AASHTO T 106 ASTM C942	"	"	"	"	–
Production									
Performance test ground anchor	Measured and tested for conformance (106.04)	Deformation	–	Subsection 256.08(b)(1)	5% or 3 min	Installation	No	5 days	–
Proof test ground anchor	"	"	–	Subsection 256.08(b)(2)	Each anchor	"	"	"	–

(1) Prepare and test grout cube specimens according to ASTM C942. Make grout cubes for testing from random batches of grout as directed. Normally, strength testing for permanent ground anchors will not be required as system performance will be measured by load holding each anchor. Grout cube testing will be required if admixtures are used or irregularities occur in anchor testing.

Section 257. — CONTRACTOR-DESIGNED RETAINING WALLS

Description

257.01 This work consists of designing various types of retaining walls. Wall types include gabion, mechanically-stabilized earth, permanent ground anchor, reinforced concrete, soil nail, reinforced soil slopes, micropiles, and other wall systems.

Material

257.02 Conform to the following Sections:

Driven piles	551
Gabions	253
Mechanically-stabilized earth walls	255
Micropiles	567
Permanent ground anchors	256
Reinforced concrete retaining walls	258
Reinforced soil slopes	261
Reinforcing steel	554
Soil nail retaining walls	259
Structural concrete	552

Construction Requirements

257.03 General. The designer/supplier furnishing the proposed retaining wall is responsible for the stability of the structure. Do not qualify the responsibility for the design or restrict the use of the drawings or calculations for the proposed alternate. Indemnify the Government from claims for infringement of proprietary rights by others without the consent of the patent holders or licensees.

Verify the limits of structure installation.

Arrange and conduct a pre-design conference following selection of the structure designer/supplier and before design work starts to discuss structure selection, constructability, and design parameters, methods and limitations. Include the CO, subcontractors, supplier, and the supplier’s design engineer.

257.04 Submittals. At least 90 days before starting construction, submit the following according to Subsection 104.03:

(a) Plan and elevation drawings for each structure containing the following:

(1) A plan view of the structure showing:

(a) Horizontal offset from the construction centerline to the face of the structure at defining points along the base, including start and end stations;

(b) Location, length, coverage ratio, and type of reinforcement/anchorage as applicable (such as strip, mesh, grid, geosynthetic fabric, anchor);

(c) Centerline and size of drainage structure or drainage pipe behind, passing through, or passing under the structure; and

(d) Location, length and offset from the face of wall to guardrail or guardwall features or parapet structures.

(2) An elevation view of the structure showing:

(a) Elevation and station at horizontal and vertical break points and at least every 50 feet (15 meters) along the top of the structure at the face;

(b) Elevation and station at the top of leveling pads and footings, at the top and tip of piling, and at least every 50 feet (15 meters) along the structure base;

(c) Length and type of reinforcement, anchorage, structure module, and lagging;

(d) Distance and elevation along the structure face to all steps in the base, footings, leveling pads, or lagging;

(e) Distance along the structure face to where changes in reinforcement or anchor lengths occur;

(f) Construction joints; and

(g) Original and final ground-line.

(3) A typical cross-section view showing:

(a) Type and depth of facing elements and structural connections to reinforcing and anchorage elements;

(b) Structure batter or face slope;

(c) Length, spacing, and type of reinforcement, anchorage, structure module and corresponding limits of excavation, and reinforced fill placement zones;

(d) Location of guardrail or guardwall features or parapet structures, including embedment depths, offset from structure facing, and connection details with structure reinforcement/anchorage;

(e) Original and final ground-line, including right-of-way limits; and

(f) Estimated or known location of subsurface soil and rock units.

(4) General construction notes.

(5) Horizontal and vertical curve data affecting the structure, including match lines or other details to relate structure stationing to centerline stationing.

(6) Material list and summary of quantities. Include the gradation for facing rock. Facing rock should be sufficiently sized to prevent migration of the rock through the facing basket for the chosen wall system.

(b) Dimensions and schedules of reinforcing steel including reinforcing bar bending details, dowels, studs, or both for attaching the facing.

(c) Details and dimensions for foundations and leveling pads including steps in the footings or leveling pads.

(d) Details and dimensions for:

(1) Panels, modules, soldier piles, and lagging necessary to construct the structure;

(2) Reinforcing steel in structural elements;

(3) Details of proposed splices in reinforcements;

(4) Location of mesh, strip attachment, or anchor devices embedded in facing panels; and

(5) Anchors and soldier piling including the spacing and size of piles and the spacing and angle of anchors.

(e) Details for the installation of structure drainage features, including strip, sheet, edge, blanket and underdrain systems, and associated piping;

(f) Details for constructing structures around drainage features, utilities, lighting foundations, traffic barriers, and other obstructions.

(g) Details for terminating structures and adjacent slope construction.

(h) Architectural treatment details.

(i) Design notes including a description of symbols, terminology, and computer programs used in the design of the structure. Specify the bearing pressure beneath the structure footing, stabilized earth mass, or soldier piles.

(j) Verification of design criteria and soil, rock and reinforcement parameters for each structure. Include results from creep, durability, construction induced damage, and junction strength tests as applicable.

(k) Design calculations, including assessment of temporary excavation stability and internal and external stability of earth retaining structures. Include joint, splice, and facing connection capacity calculations.

Include a checklist showing each of the items specified in these requirements have been addressed in the design. Submit 3 sets of drawings with the initial submission. One set will be returned with corrections if necessary. If revisions are required, make corrections and resubmit three revised sets.

257.05 Design and Construction. Design and construct the wall according to the approved drawings and the following Sections as applicable:

(a) Gabions. See Section 253.

(b) Mechanically-stabilized earth walls. See Section 255.

(c) Permanent ground anchor walls. See Sections 256, 551, and 552.

(d) Reinforced concrete retaining walls. See Section 258.

(e) Soil nail retaining walls. See Section 259.

(f) Reinforced soil slopes. See Section 261.

(g) Micropiles. See Section 567.

Update drawings when plan dimensions are revised due to field conditions or for other reasons.

257.06 Acceptance. Design of the retaining walls will be evaluated under Subsection 106.02 and the applicable Sections listed in Subsection 257.05.

Measurement

257.07 Measure the Section 257 pay items listed in the bid schedule according to Subsection 109.02.

Payment

257.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 257 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for Contractor-designed retaining walls will be paid as follows:

(a) 50 percent of the pay item amount will be paid when the design submittal is approved.

(b) An additional 25 percent of the pay item amount will be paid when 50 percent of the retaining wall construction is complete.

(c) Payment of the remaining portion of the pay item amount will be paid when 100 percent of the retaining wall construction is complete.

Section 258. — REINFORCED CONCRETE RETAINING WALLS

Description

258.01 This work consists of constructing reinforced concrete retaining walls.

Material

258.02 Conform to the following Sections and Subsections:

Forms and falsework	562
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01
Structural backfill	704.04
Structural concrete	552

Construction Requirements

258.03 General. Verify the limits of the wall installation. Prepare and submit forms, falsework drawings, and drainage provisions according to Section 562. See Section 257 for Contractor-designed reinforced concrete retaining walls.

Perform the work under Section 209.

After excavation is complete, request approval as to the character and suitability of the foundation material. Allow the CO 24 hours to review and approve the foundation before constructing the footing.

258.04 Reinforcing Steel. Submit order lists and bending diagrams according to Subsections 104.03 and 554.03. Fabricate reinforcing steel according to Subsection 554.05. Ship and protect material according to Subsections 554.04, 554.06, and 554.07. Place, fasten, and splice reinforcing steel according to Subsections 554.07, 554.08, and 554.09.

258.05 Structural Concrete. Design concrete mixture according to Subsection 552.03. Store, handle, batch, and mix material and deliver concrete according to Subsections 552.04 through 552.08. Provide quality control according to Section 153 and Subsection 552.09. Construct wall according to Subsections 552.10 through 552.16.

258.06 Backfilling. Backfill the area behind the wall with structural backfill according to Subsection 209.09. Compact each layer according to Subsection 209.10, except use an approved lightweight mechanical or vibratory compactor within 36 inches (900 millimeters) of the wall.

Do not place structural backfill against concrete until 80 percent of the design strength is achieved.

258.07 Acceptance. Reinforced concrete retaining wall material, and construction will be evaluated as follows:

Forms and falsework drawings will be evaluated under Section 562.

Structure excavation and backfill will be evaluated under Section 209.

Structural concrete will be evaluated under Section 552.

Reinforcing steel will be evaluated under Section 554.

Material for joint fillers, sealants, tie bars, dowel bars, and hook bolts will be evaluated under Subsections 106.02 and 106.03.

Measurement

258.08 Measure the Section 258 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring retaining walls by the square foot (square meter), measure by the front face of wall excluding footings.

Measure foundation fill under Section 208.

Payment

258.09 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the Section 258 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for reinforced concrete retaining wall will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is calculated as follows:

$$PF_a = 1 - 0.5\,(1-PF)$$

where:

PF = Pay factor for concrete as determined under Section 552.

Section 259. — SOIL NAIL RETAINING WALLS

Description

259.01 This work consists of constructing soil nail retaining walls.

Material

259.02 Conform to the following Section and Subsections:

Bolts and nuts	717.01(d)
Centralizers and spacers	722.02(e)
Geocomposite drain	714.02
Neat hydraulic cement grout	725.13(a)(1)
Shotcrete	566
Soil nails	722.04
Structural backfill	704.04
Structural carbon steel (bearing plates)	717.01(a)
Welded stud sheer connectors	717.05

Construction Requirements

259.03 Qualifications. Provide a professional engineer, on-site supervisors, and installation personnel with experience installing and testing soil nails. Submit the following for approval at least 30 days before starting work:

(a) Names of personnel; and

(b) A résumé for each individual describing their experience on at least five soil nail retaining wall projects of similar complexity over the past 5 years. Include project names, locations, and contact information for project owners.

259.04 Submittal. At least 30 days before starting soil nail retaining wall work, submit the following according to Subsection 104.03:

(a) Start date;

(b) Method of excavation to ensure wall and slope stability;

(c) Retaining wall construction sequence;

(d) Soil nail types, sizes, spacings, depths, and installation angles, bond zone lengths, and ultimate tendon strengths for the range of material to be encountered;

(e) Tendons, couplers, bearing plates, facing items, and additional hardware with manufacturer’s product data sheets, specifications, catalog cuts, and mill certificates;

(f) Manufacturer recommendations for tendon and hardware handling, storing, assembly, and working temperature ranges;

(g) Grout type, mix design, mixing equipment, placement procedures, and 3-day and 28-day grout compressive strength test results;

(h) Procedures and material for repairing corrosion protection coatings in the field and for applying epoxy finish coatings on end hardware;

(i) Drilling methods and equipment;

(j). Drill hole diameter to achieve the specified pullout resistance;

(k) Alternative drilling and grouting methods such as grout additives;

(l) Additional material needed to achieve required bond capacities such as grout socks;

(m) Methods to ensure borehole stability during excavation and grout placement;

(n) Soil nail testing methods and equipment including type and capacity of reaction load system, drawings, and supporting calculations for structural components of the soil nail load test apparatus; and

(o) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

259.05 General. See Section 257 for Contractor-designed soil nail retaining walls. Verify the limits of the wall installation.

Clear the work area of vegetation and obstructions according to Sections 201 and 203.

Excavate according to Section 204. Excavate for the wall in staged lifts concurrent with soil nail installation and shotcrete placement. Do not allow the exposed unsupported final excavation face cut height to exceed the vertical soil nail spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Do not excavate to the next lower lift until soil nail installation, reinforced shotcrete placement, attachment of bearing plates and nuts, and soil nail testing have been completed and accepted for the current lift. Cure grout and shotcrete at least 72 hours or attain the specified 3-day compressive strength before excavating the next underlying lift. Application of the shotcrete may be delayed up to 24 hours if it can be demonstrated the delay will not adversely affect the excavation face stability.

259.06 Tendon Fabrication. Provide tendons designed to carry loads consistent with the approved design. Thread tendon ends so they are capable of withstanding the approved test loads in addition to accommodating the attachment of the bearing plate, beveled washer, nut, or other appurtenances as required by the manufacturer’s specifications and the contract.

Limit coupling of tendons to two per installation. Use couplers manufactured with a center stop to ensure equal length of thread connects each section. Do not use couplers that interfere with the flow of grout. Protect couplings from corrosion using the same corrosion protection used on the soil nail tendon assembly. Use centralizers to position the tendon within 1 inch (25 millimeters) of the center of the drill hole. Use centralizers that do not impede the free flow of grout into the drill hole. Position centralizers within 24 inches (600 millimeters) from the top and bottom of the tendon and so their center-to-center spacing does not exceed 10 feet (3 meters). Secure centralizers to the tendon to prevent shift during handling or inserting into the drill hole.

259.07 Handling and Storing Material. See Subsection 256.06.

259.08 Installation.

(a) Drilling. Drill soil nail holes at the required locations and orientations. Use drilling equipment and methods suitable for the ground conditions. Do not use water, drilling slurry, or other fluids for drilling or removing cuttings.

Insert the soil nail tendon into the hole. Clean or redrill drill holes where the tendon with centralizers cannot be completely inserted without forcing or driving.

(b) Grouting. Use a positive displacement grout pump according to Subsection 256.07(b) (1).

Grout tendons into drill holes using a neat hydraulic cement grout. Mix grout as recommended by the cement supplier at the specified water-to-cementitious material ratio. Inject grout within 45 minutes of adding the cement to the water or within 15 minutes after mixing when the ambient temperature is 90 °F (32 °C) or higher. Do not allow the grout temperature to exceed 90 °F (32 °C).

Grout the drill hole within 2 hours of completing drilling.

Inject the grout at the lowest point of each drill hole. Place primary and secondary grout stages in one continuous operations. Keep the outlet end of the grout tube below the surface of the grout as the tube is withdrawn to prevent voids. Control grout pressures to avoid ground heaving or fracturing. Record the quantity of injected grout and the grout pressure for each soil nail installation. After grouting is complete, fill the grout tube with grout if it will remain in the hole.

Maintain the temporary unbonded length of proof test soil nails open for later grouting. If the unbonded test length of production proof test soil nails cannot be satisfactorily grouted after testing, install a new soil nail in its place.

Request approval for alternate soil nail installation methods, including grout socks, grout admixtures, or both when conditions prove necessary. Provide the CO with an on-site demonstration as part of the request.

259.09 Testing and Stressing.

(a) Testing equipment. See Subsection 256.08(a).

(b) Stressing. Place stressing equipment over the soil nail so that the jack, bearing plates, load cells, and stressing assembly are axially aligned with the tendon and the tendon is centered within the equipment. Do not apply loads greater than 80 percent of the minimum guaranteed ultimate tensile strength of the tendon for Grade 150 (1035) bars or 90 percent of the minimum guaranteed ultimate tensile strength of the tendon for Grade 60 (420) or 75 bars. Do not test soil nails until the soil nail grout and shotcrete facing have cured for at least 72 hours and attained the specified 3-day compressive strength.

Place the reference pressure gauge in series with the pressure gauge and jack so they need not be unloaded and repositioned during a test. Raise the load from one increment to another. Hold the load for the required time beginning immediately after the load is applied and record the soil nail head movement to the nearest 0.001 inch (0.025 millimeters) with respect to an independent fixed reference point. Repump the jack as necessary to maintain a constant load. Monitor the load with a pressure gauge. If the load measured by the pressure gauge and the load measured by the reference pressure gauge differ by more than 10 percent, recalibrate the jack, pressure gauge, and reference pressure gauge.

(1) Verification test. The CO will designate locations for sacrificial soil nails for verification tests.

Provide verification test soil nails with a minimum unbonded length of 3 feet (0.9 meters) and a minimum bonded length of 10 feet (3 meters).

Use the following formula to determine the maximum bonded length:

$$L_{BV\max} = \frac{Cf_y A_s}{2Q_d}$$

where:

L_{BVmax} = Maximum verification test soil nail bonded length (feet (meters))

C = 0.9 for grades 60 (420) and 75 (520) bars and 0.8 for grade 150 (1035) bars

f_y = Bar yield or ultimate stress (pounds per square inch (kilonewtons per square meter))

A_s = Bar steel area (square inches (square meters))

Q_d = Allowable pullout resistance (pounds per foot (kilonewtons per meter))

Determine the design test load by the following equation:

$$DTL = L_{BV} \times Q_d$$

where:

DTL = Design test load (pounds (kilonewtons))

L_{BV} = Bonded test length (feet (meters)) as determined from test residual elongation

Q_d = Allowable pullout resistance (pounds per foot (kilonewtons per meter))

Provide a larger bar size if necessary for safety and test according to Tables 259-1 and 259-7.

Table 259-1
Verification Test Load Schedule

Test Load Increment	Hold Time (minutes)
AL	1
0.25DTL	10
0.50DTL	10
0.75DTL	10
1.00DTL	10
1.25DTL	10
1.50DTL (Load-hold test)	60*
1.75DTL	10
2.00DTL (Maximum acceptance load)	10
2.50DTL or failure	10
3.0 DTL or failure	10
AL	1

AL = Alignment load (no greater than 5 percent of DTL (0.05DTL) applied to the soil nail before setting the movement recording devices. Zero dial gauges after the first setting of AL).

DTL = Design test load.

* Hold the load to within 2 percent and measure and record soil nail movement at 1, 2, 3, 5, 6, 10, 20, 30, 50, and 60 minutes.

A verification test is acceptable based on the criteria in Table 259-2.

Table 259-2
Verification Test Soil Nail Acceptance Criteria

Total Load-Test Hold Movement	Total Movement at Maximum Load	Pullout Failure[(1)]
< 0.080 inches (< 2 millimeters) between 6 and 60 minutes	A-line criteria: Greater than 80% of the apparent elastic elongation of the test soil nail unbonded length. B-line criteria: Less than the apparent elastic elongation of the test soil nail unbonded length and half of the bond length.	No pull-out at 2.00 DTL

(1) Pullout failure is the inability to further increase the test load while there is continued pullout movement of the test soil nail. Record the pullout failure load as part of the test data.

Provide the CO a written report confirming soil nail geometry, construction, testing details, and verification test results. The test results must be reviewed and approved by the CO before installing production soil nails.

If the soil nail verification is unacceptable, establish the cause and make design or construction modifications. Submit modifications requiring changes to the structure and retest the new system as directed by the CO.

(2) Proof tests. The CO will designate production soil nails for proof testing.

Provide production proof test soil nails with a minimum temporary unbonded length of 3 feet (0.9 meters) and a minimum bonded length of 10 feet (3 meters).

Use the following formula to determine the maximum bonded length:

$$L_{BP\max} = \frac{Cf_y A_s}{1.5Q_d}$$

where:

$L_{BP\max}$ = Maximum proof test soil nail bonded length (feet (meters))

C = 0.9 for Grade 60 (420) and 75 (520) bars and 0.8 for Grade 150 (1035) bars

f_y = Bar yield or ultimate stress (pounds per square inch (kilonewton per square meter))

A_s = Bar steel area (square inches (square meters))

Q_d = Allowable pullout resistance (pounds per foot (kilonewtons per meter))

Determine the design test load by the following equation:

$$DTL = L_{BP} \times Q_d$$

where:

DTL = Design test load (pounds (kilonewtons))

L_{BP} = Bonded test length (feet (meters)) as determined by test residual elongation

Q_d = Allowable pullout resistance (pounds per foot (kilonewtons per meter))

Test according to Tables 259-3 and 259-7.

Table 259-3
Proof Test Load Schedule

Test Load Increment	Hold Time (minutes)
AL	Until stable
0.25DTL	"
0.50DTL	"
0.75DTL	"
1.00DTL	"
1.25DTL	"
1.50DTL (Maximum acceptance load)	60*
AL	1

AL = See alignment load note in Table 259-1.

DTL = Design test load. For load and resistance factor design, DTL = Nominal load × ϕ (resistance factor) / γ (load factor).

* Hold the load to within 2 percent and measure and record soil nail movement at 1, 2, 3, 5, 6, and 10 minutes. If the soil nail movement between 1 and 10 minutes exceeds 0.04 inches (1 millimeter), continue measuring and recording soil nail movement at 20, 30, 50, and 60 minutes.

(c) Test results and reporting. Provide preliminary results to the CO for each soil nail tested before testing personnel leave the site. Submit detailed verification and proof test load and deflection data in a tabular format. Submit a graph that plots total soil nail movement versus load, the A-line, and the B-line. The A-line is defined as 0.8 multiplied by the theoretical free test length elastic elongation. The B-line is defined as the theoretical free test length elastic elongation plus 0.50 multiplied by the theoretical bond length elastic elongation. Allow 5 days for the CO to conduct a review of the data and approve ground anchor installation.

259.10 Wall Drainage Network. Install required elements of the wall drainage network, (such as geocomposite sheet drain, PVC connector pipes, and weep holes) before shotcreting each lift.

Center geocomposite sheet drains between soil nail columns with the geotextile filter side against the ground. Add additional sheet drain at wet locations and as requested by the CO. Secure sheet drains to the excavated face to prevent shotcrete from contaminating the ground side of the geotextile. Construct sheet drain splices according to the manufacturer's recommendations.

Install foot drains at the bottom of the wall according to Section 605.

259.11 Wall Construction. Place welded wire steel mesh and reinforcing steel according to Section 554.

Construct a shotcrete construction facing according to Section 566. Completely fill ungrouted zones of soil nail drill holes or other voids with shotcrete.

Attach a bearing plate and nut to each soil nail head. Uniformly seat the plate by tightening the nut with a hand wrench while the shotcrete is still plastic. Where uniform contact between the plate and the shotcrete cannot be provided, set the plate in a bed of grout and tighten the nut with a hand wrench after the grout has set for 24 hours.

Construct wall elements to tolerances shown in Table 259-4.

Table 259-4
Wall Element Construction Tolerances

Wall Element	Tolerance
Horizontal location of headed studs, from plan location	⅜ inch (10 millimeters)
Location of headed studs on bearing plate, from plan location	¼ inch (6 millimeters)
Soil nail head bearing plate, deviation from parallel to wall face	10 degrees

259.12 Permanent Wall Facing. Construct the permanent wall facing according to the applicable Section below.

(a) Shotcrete-faced walls. Construct according to Section 566 and the construction tolerances shown in Table 259-5.

(b) Concrete-faced walls. Construct according to Section 258.

(c) Simulated stone masonry. Construct according to Section 613.

(d) Stone masonry. Construct according to Section 620.

Table 259-5
Permanent Shotcrete Facing Construction Tolerances

Facing Finish	Tolerance inch (millimeter)
Complete thickness of shotcrete, from plan dimension:	
Troweled or screeded finish	⅝ (15)
Shot finish	1⅛ (30)
Planeness of finish face, surface gap under a 10-foot (3-meter) straightedge:	
Troweled or screeded finish	⅝ (15)
Shot finish	1⅛ (30)

259.13 Backfilling Behind Wall Facing Upper Cantilever Section. Backfill behind the wall with structural backfill according to Subsection 209.09. Use light mechanical tamper to compact within 36 inches (900 millimeters) behind the wall facing section.

259.14 Acceptance. See Table 259-7 for sampling, testing, and acceptance requirements.

Material for the soil nails will be evaluated under Subsections 106.03 and 106.04. Submit a production certification with each shipment of soil nails.

Construction of soil nails will be evaluated under Subsections 106.02 and 106.04.

Installed soil nails will be evaluated based on the criteria in Table 259-6.

Table 259-6
Proof Soil Nail Acceptance Criteria

Total Load-Hold Movement	Total Movement at Maximum Load	Pullout Failure[2]
< 0.040 inches (< 1 millimeter) between 1 and 10 minutes or < 0.080 inches (< 2 millimeters) between 6 and 60 minutes[1]	A-line criteria: Greater than 80% of the apparent elastic elongation of the test soil nail unbonded length. B-line criteria: Less than the apparent elastic elongation of the test soil nail unbonded length and half of the bond length.	No pull-out at 1.50 DTL

(1) And the rate of movement is linear or decreasing throughout the load-hold period.

(2) Pullout failure is the inability to further increase the test load while there is continued pullout movement of the test soil nail. Record the pullout failure load as part of the test data.

If a proof-tested soil nail is unacceptable, replace some or all of the installed production soil nails between the unacceptable proof test soil nail and the next proof test soil nail in the row, as directed by the CO. Alternatively, install additional proof test soil nails within this area to ensure that the acceptance criteria is met within this area. Propose alternative installation and testing methods before installing additional soil nails. When ground conditions, soil nail installation methods, or testing procedures change, conduct additional verification testing before proceeding with production soil nail installation.

Measurement

259.15 Measure the Section 259 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring soil nail retaining walls by the square foot (square meter), measure the front wall face.

When verification test soil nails are measured by the each; do not measure failed verification test soil nails or additional verification test soil nails installed to verify alternative soil nail installation methods proposed by the Contractor.

When production soil nails are measured by the linear foot (meter); measure along bar centerline from the line of the wall excavation face to the tip of the soil nail.

Payment

259.16 The accepted quantities will be paid for at the contract price per unit of measurement for the Section 259 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 259-7
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Neat hydraulic cement grout (725.13(a)(1))	Measured and tested for conformance (106.04)	Compressive strength(1)	–	AASHTO T 106	1 per mix design	Source of material	Yes	30 days before production	–
Production									
Verification test soil nail	Measured and tested for conformance (106.04)	Performance	–	Subsection 259.09(b)(1)	Each soil nail	Installed	No	7 days	–
Proof test soil nail	"	"	–	Subsection 259.09(b)(2)	"	"	"	5 days	–

(1) At 3-day and 28-day.

Section 260. — ROCK BOLTS AND DOWELS

Description

260.01 This work consists of furnishing and installing rock bolts and dowels.

Rock bolts are pre- or post-tensioned, fully grouted, deformed steel bars that actively reinforce a rock mass.

Rock dowels are untensioned, fully grouted deformed steel bars that passively reinforce a rock mass.

Material

260.02 Conform to the following Section and Subsections:

Minor concrete	601
Nonshrink grout	725.13(b)
Polyester resin grout	725.13(d)
Reinforcing bars (dowels)	709.01(b)
Rock bolts	722.03

Construction Requirements

260.03 Qualifications. Provide a professional engineer, on-site supervisors, and installation personnel with experience installing and testing rock bolts or dowels. Submit the following for approval at least 30 days before starting work:

(a) Names of personnel; and

(b) A résumé for each individual describing their experience on at least five rock bolt or dowel projects of similar complexity over the past 5 years. Include project names, locations, and contact information for project owners.

260.04 Submittals. At least 30 days before starting bolt or dowel installation work, submit the following according to Subsection 104.03:

(a) Start date;

(b) Method of access, excavation, scaling and drilling;

(c) Rock bolt or dowel construction sequence;

(d) Rock bolt or dowel type, length, and diameter. If threads are cut into deformed bars, size the bar based on the loads specified;

(e) Couplers, bearing plates, washers, and stressing anchorages with manufacturer’s product data sheets, specifications, catalog cuts, and mill certificates;

(f) Manufacturer recommendations for tendon and hardware handling, storing, and working temperature ranges;

(g) Grout type, mix design, placement procedures, and manufacturer's product data sheets;

(1) Polyester resin grout.

(a) Manufacturer certification for gel time, shelf life, compressive strength, and storage and working temperature ranges; and

(b) Number, diameter, and length of resin cartridges with bar spin speed, travel speed, and spin time for each tendon and hole size combination.

(2) Cement grout. Mixing equipment and 3-day grout compressive strength test results.

(a) Two-stage cement grouting. Means for determining the level of primary grout in the hole; and

(b) Single-stage cement grouting. Fabrication details for proposed bond-breaker in the free stressing zone, when applicable.

(h) Manufacturer certification for corrosion-resistant bar coating and procedures and material for repairing corrosion protection coatings in the field;

(i) Details for placing, stressing and testing tendons. Schedule of a test installation to demonstrate rock bolt or dowel installation, testing equipment and procedures, and countersink finishing if applicable;

(j) For rock bolts, a detailed procedure for placing the anchor head assembly (bearing plate and nut) below the exposed rock surface or for removing the anchor head assembly following final lock-off without impacting the tendon design load. Include details for a countersink and colored grout, or epoxy patch when applicable;

(k) Methods for verifying hole diameters;

(l) Special installation methods (such as upwardly inclined reinforcements, grouting across open joints, or debris-filled discontinuities used to ensure a fully-grouted, well-protected installation) when applicable;

(m) Report documentation examples including installation and testing report formats; and

(n) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

260.05 Rock Bolt Fabrication.

(a) General. Fabricate rock bolts according to PTI, *Recommendations for Prestressed Rock and Soil Anchors*. Size tendons to ensure:

(1) The design load does not exceed 60 percent of minimum ultimate tensile strength of the tendon; and

(2) The maximum test load does not exceed 80 percent of the minimum ultimate tensile strength of the tendon.

(b) Couplers. Couple only fully-grouted anchors. Couple sections together only when the design length exceeds the standard commercially available bar lengths. Use couplers with a center stop to ensure equal length of thread connects each section. Do not use couplings that interfere with the flow of grout.

(c) Anchorage. For the stressing anchorage, use a steel bearing plate, washers (flat hardened, beveled or spherical, as required), and a nut capable of developing 95 percent of the minimum ultimate tensile strength of the tendon.

(d) Centralizers. For cement grouted rock bolts, place centralizers along the tendon at 8-foot (2.5-meter) centers, with at least one centralizer per rock bolt. Locate the lowermost centralizer within 12 inches (300 millimeters) of the end. Use centralizers of sufficient strength to support the anchor bar in the drilled hole.

260.06 Handling and Storing Material. Handle and store tendons according to ASTM D3963, the manufacturer's recommendations, and Subsection 256.06.

Store polyester resin grout cartridges according to the manufacturer's recommendations. Do not use polyester resin grout cartridges that are expired, damaged, frozen, hardened, or otherwise defective.

260.07 Installation.

(a) Drilling. Provide equipment capable of drilling straight and uniform-diameter holes. Do not use water or drilling slurry. Drill rock bolt and dowel hole collars and hole depths within 6 inches (150 millimeters) of the required location and depth. Size drill holes to provide at least 0.5 inches (13 millimeters) of grout cover over the bond zone portion of the tendon. Clean drill holes of cuttings, sludge, and debris.

(b) Grouting. Install the rock anchor within 24 hours of completing the drill hole. Orient reinforcement within 5 degrees of the specified angle.

(1) Cement grout installations. Use a positive displacement grout pump according to Subsection 256.07(b)(1).

Install the tendon and batch and inject grout according to the manufacturer's recommendations. For single-stage cement-grouted tendons, do not grout beyond the top of the bond-breaker assemblage along the free-stressing length before tensioning the tendon. Place the grout in one continuous operation. Control grout pressures to avoid ground heaving or fracturing. Fill the grout tube with grout if it will remain in the hole.

Record the quantity of injected grout and the grout pressure for each installation. Notify the CO of grout quantity overruns including the reason for the overrun and proposed actions to minimize future overruns. Obtain approval for alternative grouting methods.

(2) Resin grout installations. Insert the approved number and size of resin cartridges to fully cover the bond zone and fill the drill hole to the collar. Follow the approved procedures for tendon spin speed, travel speed, and spin time for resin used. Use spin adapters during tendon installation to avoid damaging the finished end tendon threads.

(a) Rock bolts. Fully grout the bond zone with fast-set resin and the remainder of the hole with slow-set resin or cement grout for combination grout installations.

(b) Rock dowels. Use a single resin grout with set time sufficient for complete installation.

(c) Bearing plate installation. Place the bearing plate so at least three quarters of the plate's surface is in contact with a rock face. Construct a bearing pad approved by the CO if the rock face is irregular or unsound or the axis of the tendon is greater than 20 degrees from perpendicular to the bearing plate when the axis of the tendon passes through the center of the bearing plate without bending the tendon. Use beveled washers if the axis of the tendon is greater than 5 degrees from perpendicular to the bearing plate. Allow at least 4 inches (100 millimeters) of tendon length beyond the nut.

For dowels, when the grout has reached final set per the manufacturer's recommendations or a minimum compressive strength of 60 percent of the 7-day compressive strength; install the bearing plate, washers and nut, and apply a torque of 100 foot-pounds (135 newton-meters) to ensure proper seating against the rock face.

After load-testing, tension and lock-off of rock bolts, place non-structural filler (cement grout or polyester resin grout) for the entire free stressing length. Remove excess grout from the rock face and anchor assembly.

Paint exposed parts of the rock bolt, bearing plate, and nut with an approved corrosion-protection paint or epoxy patching compound. When covers are required, rock bolt the anchorage cover to the bearing plate and completely fill cover with grout after the rock anchor has been tested and finally locked-off. After the grout has achieved initial set, demonstrate to the CO that the anchorage cover is completely filled with grout.

For rock bolt and dowel installations, ensure the tendon is fully grouted to the collar of the hole.

260.08 Rock Bolt Testing, Stressing, and Finishing. Conduct testing of tensioned and untensioned rock bolts according to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

Trim the corrosion protection surrounding the free stressing length of the tendon so it does not contact the bearing plate during testing and stressing. For single-stage cement-grouted tendons, tension the tendon after the bond zone grout is set and reaches sufficient pull-out strength. For two-stage cement-grouted tendons, tension the tendon after the bond zone grout is set and reaches sufficient pull-out strength and before the free stressing length is grouted. For resin-grouted tendons, tension the tendon after the fast-set resin fully sets in the bond zone and before the slow-set resin begins to set in the free stressing length. For mechanically-anchored tendons, tension the tendon immediately following insertion in the hole and before fully grouting.

(a) Performance tests. Use the same equipment, tendons, drill hole specifications, grout, post-tensioning, and installation methods as used for production installations to verify required bond strengths in the anchorage zone before final grouting of the stressing length. For two-stage grouted, post-tensioned rock bolts and single-stage, grouted, post-tensioned rock bolts employing bond breakers, conduct performance tests on sacrificial or production installations. For pre-tensioned installations, conduct performance tests on sacrificial installations. When changes or modifications in the equipment, tendons, drill hole specifications, or installation methods occur; conduct another performance test as approved by the CO.

Tension rock bolts to 120 percent of the design load with a calibrated hollow-ram hydraulic jack for a holding time of not more than 60 minutes. Take load and extension measurements during tensioning with a measuring device (such as a dial gauge or vernier scale) capable of measuring to 0.001 inches (0.025 millimeters). A rock bolt is acceptable if both of the following conditions are satisfied:

(1) The total elastic movement obtained at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the free stressing length; and

(2) The rock bolt will carry the maximum test load with a creep rate that does not exceed 0.04 inches (1 millimeter) between 1 and 10 minutes or 0.08 inches (2.0 millimeters) per log cycle between the 6 and 60 minute readings.

Perform at least two successful performance tests for each different rock unit, anchor type, and proposed drilling-installation-grouting method before beginning production rock bolt installation. When a performance test fails, modify the design or construction procedure as needed and conduct another performance test on a replacement production installation. Conduct performance tests at locations approved by the CO.

(b) Proof tests. Conduct proof testing on production pre- and post-tensioned rock bolt installations. Proof test each production rock bolt to 120 percent of the design load. If no loss of load occurs in 10 minutes the rock bolt is approve. When a proof test fails or results vary significantly from the performance test result, document the expected reasons for failure, modify the design or construction procedure and conduct an additional performance test on a replacement production rock bolt installation. Obtain approval from the CO for the location of replacement anchors.

After tensioning and achieving a successful rock bolt proof test, lock off the load at 100 percent of the design load and grout the remaining portion of the rock bolt, as appropriate.

260.09 Rock Dowel Lift-Off Testing and Finishing. Conduct testing of rock dowels according to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

Test only fully grouted dowels. Conduct at least five successful lift-off tests in succession for each different rock unit, anchor type, and proposed drilling-installation-grouting method. Gradually load lift-off test reinforcements to 60 percent of the minimum ultimate tensile strength of the dowel tendon and monitor the pressure gage to verify the anchor is holding the design load for at least 10 minutes. If the anchors do not pull out, test 5 percent of the remaining dowels. If pressure is lost on the pressure gage due to anchorage movement, replace the dowel and conduct lift-off tests on an additional five anchors in succession until all are satisfactory.

260.10 Test Results and Reporting. Submit test results to CO for review. Maintain daily records of rock bolt and dowel work in a manner acceptable to the CO, including:

(a) As-built drawings depicting the location of each anchor, noting anchor designation, date drilled and grouted, total anchor length, bonded length, free stressing length, grout mix, grout volume, average grout pressure, hole diameter, size of tendon, tendon inclination, and installation comments. Submit as-built drawings according to Section 104 after work completion.

(b) Performance and proof test data forms, including the anchor designation, bonded length, free stressing length, stressing length, date of stressing operation, signature of stressing operator or inspector, required elongation and associated gage pressure, actual elongation and associated gage pressure, identification numbers of jacking equipment, comments, and a table including incremental jack pressure, jack load, and movement.

260.11 Acceptance. See Table 260-1 for sampling, testing, and acceptance requirements.

Material for rock bolts and dowels will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of rock bolts and dowels will be evaluated under Subsections 106.02 and 106.04.

Grouting will be evaluated under Subsections 106.02 and 106.04.

Installed rock bolts and dowels will be evaluated under Subsections 106.02 and 106.04.

Measurement

260.12 Measure the Section 260 pay items listed in the bid schedule according to Subsection 109.02.

Payment

260.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 260 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 260-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (fine) (703.01)	Measured and tested for conformance (106.04 & 105)	Quality	–	AASHTO M 6	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Grout (725.13(b))	Measured and tested for conformance (106.04)	Flow	–	ASTM C939	1 per mix design	Source of material	Yes, when requested	Before producing	–
		Compressive strength (3-day)	–	ASTM C942	"	"	"	"	–
Production									
Performance test for rock bolts	Measured and tested for conformance (106.04)	Deformation	–	Subsection 260.08(a)	Subsection 260.08(a)	Installation	No	24 hours	–
Proof test for rock bolts	"	"	–	Subsection 260.08(b)	Each bolt	"	"	"	–

Table 260-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Lift-off test for rock dowel	Measured and tested for conformance (106.04)	Deformation	–	Subsection 260.09	Subsection 260.09	"	"	"	–

Section 261. — REINFORCED SOIL SLOPES

Description

261.01 This work consists of constructing reinforced soil slopes.

Material

261.02 Conform to the following Subsections:

Backfill material	704.03
Reinforcement geotextile and geogrid	714.04

Construction Requirements

261.03 Submittals. At least 30 days before starting reinforced soil slope construction, submit the following according to Subsection 104.03:

(a) Manufacturer's certification. Certification and test results indicating the proposed soil reinforcement, reinforced embankment, and facing material meets requirements;

(b) Splice details. Detail proposed splices in soil reinforcement; and

(c) Facing details. Provide installation methods and connection details for facing system.

261.04 General. See Section 257 for Contractor-designed reinforced soil slope systems.

Verify the limits of the reinforced soil slope installation.

Clear the area of vegetation and obstructions according to Sections 201 and 203.

Conserve topsoil according to Subsection 204.05.

Prepare and compact foundation soils according to Subsection 204.09. Grade the foundation soils supporting the reinforced soil slope for a width equal to the length of the lowest soil reinforcement level. Bench cut slope surfaces to key the reinforced soil slope into the existing embankment.

261.05 Soil Reinforcement and Facing. Lay each layer of soil reinforcement flat, pull tight, and hold in place with pins, soil piles, or other approved methods. Construct the reinforced soil slope to achieve the slopes specified and roadbed tolerances according to Subsection 204.13(d).

Grade and compact backfill material according to Subsections 204.09 and 204.11 before placing the next soil reinforcement layer. Maintain a minimum cover of 6 inches (150 millimeters) over the reinforcement during spreading and compacting of fill material. Avoid sudden stops, starts, or turns of the equipment. Do not use sheepsfoot-rollers. Use lightweight mechanical tampers, rollers, vibratory systems, or other methods for compaction within 36 inches (900 millimeters) of the slope face.

Place backfill material in a manner that tensions the reinforcement working from the slope face to the back of reinforcement.

Do not leave reinforcement exposed at end of shift. At the end of each shift, shape to drain and compact the work area to a uniform cross-section. At the end of the day's operation, slope the last lift of backfill away from the slope face to direct surface runoff away from the slope.

261.06 Acceptance. Material for reinforced soil slopes will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of reinforced soil slopes will be evaluated under Subsections 106.02 and 106.04.

Excavation will be evaluated under Section 204.

Measurement

261.07 Measure the Section 261 pay items listed in the bid schedule according to Subsection 109.02.

When measuring reinforced soil slope backfill within the stabilized volume by the cubic yard (cubic meter), measure in place.

Payment

261.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 261 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 300
AGGREGATE AND BASE COURSES

Section 301. — UNTREATED AGGREGATE COURSES

Description

301.01 This work consists of constructing one or more courses of aggregate on a prepared surface.

Subbase and base aggregate grading is designated according to Table 703-2. Surface course aggregate grading is designated according to Table 703-3.

Material

301.02 Conform to the following Subsections:

Subbase, base, and surface course aggregate	703.05
Water	725.01(c)

Construction Requirements

301.03 General. Prepare the surface on which the aggregate course is placed according to Section 204 or 303 as applicable.

After a representative quantity of aggregate is produced, submit proposed target values for the appropriate sieve sizes along with a representative 300-pound (150-kilogram) sample at least 14 days before incorporating the aggregate into the work.

Set target values within the gradation ranges shown in Table 703-2 or 703-3 for the required grading.

301.04 Mixing and Spreading. Determine the optimum moisture content according to AASHTO T 180, Method D. Mix the aggregate and adjust the moisture content to obtain a uniform mixture with a moisture content within 2 percent of the optimum moisture content. Spread and shape the mixture on the prepared surface in a uniform layer.

Do not place the mixture in a layer exceeding 6 inches (150 millimeters) in compacted thickness. When more than one layer is necessary, compact each layer according to Subsection 301.05 before placing the next layer. Route hauling equipment uniformly over the full width of the surface to minimize rutting or uneven compaction.

301.05 Compacting. Determine the maximum density of the mixture according to AASHTO T 180, Method D.

Compact each layer full width. Roll from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

Compact each layer to at least 95.0 percent of maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

301.06 Surface Tolerance. If grade finishing stakes are required, finish the surface to within ±0.05 feet (±10 millimeters) from staked line and grade elevation.

If grade finishing stakes are not required, shape the surface to the required template and check the surface with a 10-foot (3-meter) straightedge. Defective areas are surface deviations in excess of ½ inch (13 millimeters) in 10 feet (3 meters) between two contacts of the straightedge with the surface.

Correct defective areas by loosening the material, adding or removing material, reshaping, and compacting.

301.07 Maintenance. Maintain the aggregate course to the correct line, grade, and cross-section by blading, watering, rolling, or combination thereof until placement of the next course. Correct defects according to Subsection 301.06.

301.08 Acceptance. See Table 301-1 for sampling, testing, and acceptance requirements; including the category for quality characteristics.

Aggregate gradation and surface course plasticity index will be evaluated under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

(a) Aggregate gradation. The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Tables 703-2 and 703-3, except as follows:

(1) If the calculated mean value for a tested sieve exceeds the maximum gradation value shown in Table 703-2 or 703-3, then the upper specification is equal to the maximum gradation value plus the allowable deviation, and the lower specification is equal to the maximum gradation value minus the allowable deviation.

(2) If the calculated mean value for a tested sieve is less than the minimum gradation value shown in Table 703-2 or 703-3, then the upper specification is equal to the minimum gradation value plus the allowable deviation and the lower specification is equal to the minimum gradation value minus the allowable deviation.

(b) Plasticity index. The upper and lower specification limits for surface courses are shown in Subsection 703.05(c)(3).

Construction of untreated aggregate courses will be evaluated under Subsections 106.02 and 106.04.

Measurement

301.09 Measure the Section 301 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring aggregate by the cubic yard (cubic meter), measure in place.

When measuring aggregate by the square yard (square meter), measure the length horizontally along the centerline of the roadway. Measure the width horizontally to include the top of aggregate width, including designed widenings.

Payment

301.10 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the Section 301 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 301-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (703.05(a) (b) (c))	Measured and tested for conformance (106.04 & 105)	LA abrasion (coarse)	–	AASHTO T 96	1 per type & source of material	Source of material	Yes	Before using in work	Not required when using Government-provided sources
		Soundness using sodium sulfate (coarse & fine)	–	AASHTO T 104	"	"	"	"	"
		Fractured faces	–	ASTM D5821	"	"	"	"	"
		Liquid limit	–	AASHTO R58 & T 89, Method A	"	"	"	"	"
Surface course aggregate (703.05(c))	"	Plasticity index	–	AASHTO R 58, T 89, & T 90	"	Crusher belt or after processing	"	"	"

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source (continued)									
Subbase, base, or surface course aggregate (703.05(b) (c))	Process control (153.03)	Gradation	–	AASHTO T 11 & T27	2 per day per stockpile (minimum)	Crusher belt	No	24 hours	Not required when using a pre-crushed commercial source
		Fractured faces	–	ASTM D5821	"	"	"	"	"
Surface course aggregate (703.05(c))	"	Plasticity index	–	AASHTO R 58, T 89, & T 90	"	Crusher belt or after processing	"	"	"
Production									
Subbase course Grading A & B	Statistical (106.05)	Gradation No. 4 (4.75 mm) No. 200 (75µm) Other specified sieves	 I I II	AASHTO T 27 & T 11	1 per 1000 tons (900 metric tons)	From windrow or roadbed after processing	Yes	4 hours	–

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Base course Grading C, D, & E	Statistical (106.05)	Gradation ⅜ inch (9.5 mm) No. 4 (4.75 mm) No. 200 (75µm) Other specified sieves	 I I I II	AASHTO T 27 & T 11	1 per 1000 tons (900 metric tons)	From windrow or roadbed after processing	Yes	4 hours	–
Subbase & base course Grading A, B, C, D, & E	Measured and tested for conformance (106.04)	Liquid limit	–	AASHTO R 58 & T 89, Method A	1 per 1000 tons (900 metric tons)	From windrow or roadbed after processing	Yes	4 hours	–
		Moisture-density (max density)	–	AASHTO T 180, Method D [(1)]	1 per type & source of material	Stockpile or production output	"	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 500 tons (450 metric tons)	In-place after compaction	No	End of shift	–
		Moisture content (in-place)	–	"	"	"	"	"	–

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Surface course aggregate	Statistical (106.05)	Gradation		AASHTO T 27 & T 11	1 per 1000 tons (900 metric tons)	From windrow or roadbed after processing	Yes	4 hours	–
		No. 4 (4.75 mm)	I						
		No. 40 (4.75 µm)	I						
		No. 200 (75 µm)	I						
		Other specified sieves	II						
		Plasticity index	I	AASHTO R 58, T 89, & T 90	"	"	"	"	–
	Measured and tested for conformance (106.04)	Moisture-density (max density)	–	AASHTO T 180, Method D [(1)]	1 per type & source of material	Stockpile or production output	Yes	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 500 tons (450 metric tons)	In-place after compaction	No	End of shift	–
		Moisture content (in-place)	–	"	"	"	"	"	–
		Fractured faces	–	ASTM D5821	1 per 1000 tons (900 metric tons)	From windrow on roadbed after processing	Yes	4 hours	–

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Subbase, base, and surface course	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Surface of final course	No	Before placement of next layer or as requested	–

(1) Minimum of 5 points per proctor.

Section 302. — MINOR CRUSHED AGGREGATE

Description

302.01 This work consists of furnishing and placing crushed aggregate for bedding, backfill, and roadway aggregates on a prepared surface.

Material

302.02 Conform to the following Subsections:

Crushed aggregate	703.06
Water	725.01(c)

Construction Requirements

302.03 Preparing Surface.

(a) Roadway aggregate. Prepare the surface on which the aggregate course is placed according to Section 303.

(b) Bedding and backfill aggregate. Shape, compact, and finish the surface to the required lines, grade, elevation, and cross-section according to Section 209.

302.04 Placing Crushed Aggregate.

(a) Roadway aggregate. Mix the aggregate and adjust the moisture content to obtain a uniform mixture. Adjust the moisture content to obtain proper compaction. Spread and shape in uniform layers not to exceed 6 inches (150 millimeters) compacted thickness. Where more than one layer is necessary, compact the underlying layer according to Subsection 302.05.

(b) Bedding and backfill aggregate. Place and shape the mixture in layers that, when compacted, do not exceed 6 inches (150 millimeters) in depth.

302.05 Compacting and Finishing Crushed Aggregate.

(a) Roadway aggregate. When no compaction method is specified, use either method. Finish surface according to Subsection 301.06.

(1) Method 1. Compact each layer according to Subsection 204.11(a). Roll from the sides to the center, parallel to the centerline of the road. Compact the material along curbs, headers, walls, and places not accessible to a roller with approved tampers or compactors.

Compactive effort may be decreased if in-place densities show that less compactive effort is required under Method 2.

(2) Method 2. Compact each layer according to Subsection 301.05.

(b) Bedding and backfill aggregate. Compact each layer according to Subsection 209.10.

302.06 Acceptance. See Table 302-1 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsections 106.02 and 106.03. Submit a production certification including gradation and quality properties for each source.

Construction of roadway aggregate courses will be evaluated under Subsections 106.02 and 106.04. Method 2 compaction will be evaluated under Subsection 106.04.

Placement of bedding and backfill aggregate will be evaluated under Subsections 106.02 and 106.04.

Measurement

302.07 Measure the Section 302 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring crushed aggregate by the cubic yard (cubic meter), measure in place.

When measuring aggregate by the square yard (square meter), measure the length horizontally along the centerline of the roadway. Measure the width horizontally to include the top of aggregate width, including designed widenings.

Payment

302.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 302 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 302-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Crushed aggregate	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D (1)	1 per aggregate supplied	Production output or stockpile	No	4 hours	–
		Density	–	AASHTO T310 or other approved procedures	1 per 500 tons (450 metric tons)	In-place after compaction	"	End of shift	For Method 2 compaction only
Crushed aggregate	Process control (153.03)	Moisture content (in-place)	–	"	"	"	"	"	–
Finished Product									
Crushed aggregate	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Surface of final course	No	Before placement of next layer or as requested	–

(1) Minimum of 5 points per proctor.

Section 303. — ROAD RECONDITIONING

Description

303.01 This work consists of reconditioning ditches, shoulders, roadbeds, aggregate surfaces, or the entire road.

Material

303.02 Conform to the following Subsection:

Water	725.01(c)

Construction Requirements

303.03 Ditch Reconditioning. Remove slide material, sediment, vegetation, and other debris from existing ditches and culvert inlets/outlets. Reshape ditches and culvert inlets/outlets to achieve positive drainage and uniform ditch width, depth, and grade. Dispose of waste at designated sites or according to Subsection 204.14.

303.04 Shoulder Reconditioning. Remove slide material, vegetation, and other debris from existing shoulders including shoulders in parking areas, turnouts, and other widened areas. Repair soft and unstable areas according to Subsection 204.07. Reshape shoulders to the widths and slopes shown in the plans. Dispose of waste at designated sites or according to Subsection 204.14.

303.05 Roadbed Reconditioning. Remove organic, deleterious, and material larger than 6 inches (150 millimeters) from the top 6 inches (150 millimeters) of subgrade. Dispose of waste according to Subsection 204.14. Repair soft and unstable areas according to Subsection 204.07. Scarify surface to a 6-inch (150-millimeter) depth. Remove irregularities and shape to a uniform surface. Finish earth surfaces to within 0.05 feet (15 millimeters) and rock surfaces to within 0.10 feet (30 millimeters) of required line, grade, and cross-section. Compact according to Subsection 204.11.

303.06 Aggregate Surface Reconditioning. Repair soft and unstable areas to the full aggregate surface depth and according to Subsection 204.07. Scarify the thickness of aggregate surfacing material or to 6 inches (150 millimeters), whichever is less. Remove irregularities and shape to a uniform surface. Finish and compact the surface according to Subsection 302.05.

303.07 Roadway Reconditioning. Perform applicable work described in Subsections 303.03 through 303.06. Maintain existing cross slope and crown or as shown in the plans.

303.08 Acceptance. See Table 303-1 for sampling, testing, and acceptance requirements.

Road reconditioning work will be evaluated under Subsections 106.02 and 106.04.

Measurement

303.09 Measure the Section 303 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure waste under Section 204.

Payment

303.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 303 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 303-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Existing roadbed material or aggregate surfacing	Measured and tested for conformance (106.04)	Classification	–	AASHTO M 145	1 per soil type	Roadbed	Yes	Before using in work	–
		Moisture-density	–	AASHTO T 180, Method D [(1)] or AASHTO T 99, Method C[(1)]	1 per mixture or change in material	Processed material	No	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 2000 yd^2 (1700 m^2)	In-place after compaction	"	End of shift	For Subsection 204.11(c) cases only
	Process control (153.03)	Moisture content (in-place)	–	"	"	"	"	"	–
Finished Product									
Aggregate surface reconditioning (303.06)	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determine by the CO	Surface of final course	No	Before placement of next layer or as requested	–

(1) Minimum of 5 points per proctor.

Section 304. — FULL DEPTH RECLAMATION

Description

304.01 This work consists of pulverizing an existing pavement and base in-place, adding crushed aggregate if required, mixing this material with water, and shaping and compacting the mix to produce a base.

Material

304.02 Conform to the following Subsections:

Crushed aggregate	703.06
Water	725.01(c)

Construction Requirements

304.03 General. Establish profile and cross slope control. Maintain the existing cross slope or crown if none is established.

Before pulverizing, remove and dispose of unsuitable material as directed by the CO. Replace unsuitable material with crushed aggregate according to Subsection 304.04.

Protect manholes, valve covers, and other buried facilities from damage.

304.04 Adding Crushed Aggregate. If required, add crushed aggregate to bring the finished surface to the established line, grade, and cross-section.

304.05 Pulverizing. Furnish a road reclaimer that is:

(a) Self-propelled;

(b) Specifically manufactured for in-place reclamation;

(c) Capable of reducing the existing material to the required size;

(d) Equipped with at least an 8-foot (2.4-meter) cutting width;

(e) Equipped with standard automatic depth controls adjustable in increments of ½ inch (13 millimeters); and

(f) Equipped with sufficient horsepower to constantly pulverize to the required depth in a single pass.

Use the reclaimer to pulverize the existing roadway material, in-place until 100 percent passes the 2-inch (50-millimeter) sieve. Reprocess or remove larger particles and dispose of them according to Subsection 203.05.

304.06 Mixing and Spreading. Add water as necessary to adjust the moisture content of the mixture to within 2 percent of the optimum for compaction. Mix to produce a homogenous full depth mixture. Spread the mixture uniformly across the existing roadbed to provide a final compacted shape according to the established line, grade, and cross-section.

304.07 Compacting. Compact using one of the following methods:

(a) Method 1. Compact material full width according to Subsection 204.11(a).

(b) Method 2. Compact material according to Subsection 301.05.

304.08 Surface Tolerance. See Subsection 301.06.

304.09 Maintenance. See Subsection 301.07. Overlay the base within 14 days after compacting.

304.10 Acceptance. See Table 304-1 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsection 106.03.

Construction of full depth reclamation will be evaluated under Subsections 106.02 and 106.04.

Measurement

304.11 Measure the Section 304 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure crushed aggregate under Section 302.

Measure removal and disposal of unsuitable material under Sections 203 and 204.

Payment

304.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 304 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 304-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Pulverized material	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D (1)	1 per change in material	Behind reclaimer before compaction	Yes	Before using in work	–
		Density	–	AASHTO T 310	1 per 2,000 yd^2 (1,700 m^2)	In-place after compaction	No	End of shift	For Method 2 compaction only
	Process control (153.03)	Moisture content (in-place)	–	AASHTO T 255 or other approved methods	Minimum 1 per 3500 yd^2 (3000 m^2)	"	"	Upon completion of test	–
		Gradation	–	AASHTO T 27	"	Behind reclaimer before compaction	"	"	Minus 2-inch (50-mm) sieve requirement only
Finished Product									
Finished pulverized material	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Completed FDR surface	No	Before placement of next layer or as requested	–

(1) Minimum of 5 points per proctor.

Section 305. — FULL DEPTH RECLAMATION WITH CEMENT

Description

305.01 This work consists of pulverizing an existing pavement and base in-place, adding crushed aggregate if required, mixing this material with cement and water, and shaping and compacting the mix to produce a stabilized base.

Material

305.02 Conform to the following Subsections:

Crushed aggregate	703.06
Hydraulic cement	701.01
Water	725.01(c)

Construction Requirements

305.03 Proportioning. Collect representative samples of the pavement and base from the project. Process and blend these material to achieve a gradation representative of the in-place pulverized material.

Estimate the median cement content by mass to meet the requirements of Table 305-1. At this median cement content and at cement contents 2 percent above and below this median, determine the optimum moisture content, maximum density, and the parameters included in Table 305-1.

Table 305-1
Soil-Aggregate-Cement Mix Design Parameters

Material or Property	Requirement
Unconfined compressive strength, ASTM D1633, Method A(1)	
Average strength (3 specimens)	200 psi (1.4 MPa) min.
Maximum strength of a single specimen break	400 psi (2.8 MPa) or less
Loss in mass, AASHTO T 135 & AASHTO T 136, 12 cycles	14% max.

(1) At 7-day cure at 70 °F (21 °C) according to ASTM D1632.

Submit a mix design for approval 30 days before production which includes the following:

(a) Optimum cement content conforming to the requirements of Table 305-1;

(b) Maximum density and moisture content at the optimum cement content according to AASHTO T 134, minimum of 4 points;

(c) Source of each component material;

(d) Results of all tests and applicable charts and graphs;

(e) Gradation and proportion of imported crushed aggregate;

(f) 200-pound (90-kilogram) sample of the pavement, base, and imported crushed aggregate, if requested; and

(g) 20-pound (9-kilogram) sample of Portland cement, if requested.

Begin production only after the mix design is approved. Submit a new mix design if the CO requests due to a change in material.

305.04 General. See Subsection 304.03.

305.05 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-stabilization preparatory phase meeting at least 7 days before the start of stabilizing operations according to Subsection 153.04(a).

(b) Control strip. Provide 7 days notice before beginning production.

On the first day of production, stabilize a 1000-foot (300-meter) control strip, one-lane wide, at the designated lift thickness and mix design proportions. Construct the control strip on the project at an approved location.

Construct the control strip using construction procedures intended for the entire project. Take nuclear gauge density readings behind each roller pass to determine the roller pattern necessary to achieve the specification requirements in Subsection 305.10. Cease production after construction of the control strip until the stabilized base layer and the control strip are evaluated for acceptance.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in unacceptable control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed base. When a control strip is accepted, full production may begin.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the beginning of a new construction season.

305.06 Adding Crushed Aggregate. See Subsection 304.04.

305.07 Pulverizing. See Subsection 304.05.

305.08 Applying Cement. Do not add cement when the underlying surface is frozen, muddy, or when conditions allow for excessive loss to eroding or blowing. Begin cement application when the air temperature is above 40 °F (5 °C) and is expected to stay above 40 °F (5 °C) for 48 hours. Apply cement by one of the following methods:

(a) Dry method. Use a metered mechanical spreader to uniformly apply the cement. Use canvas (or similar) skirts around the spreader box to minimize dust.

(b) Slurry method. Use approved equipment and dispersal processes to uniformly apply a cement and water slurry without pooling or run off. Equip slurry tanks with an agitator to keep the cement suspended in water. Apply the slurry to the pulverized material with 60 minutes from time water first contacts the cement. Make successive passes over the material if necessary to obtain the proper moisture and cement content for mixing and compacting.

305.09 Mixing. Begin mixing within 30 minutes after cement application. Use a road reclaimer conforming to Subsection 304.05. Add water as necessary to adjust the moisture content of the mixture to within 2 percent of optimum as indicated in the approved mix design. Continue mixing until the cement is uniformly distributed within the in situ material creating a homogeneous full depth layer. Complete mixing within 1 hour of the cement application.

305.10 Compacting and Finishing. Compact the processed material uniformly to at least 95 percent of maximum density as determined from AASHTO T 134. Furnish rollers sized and configured to achieve the required compaction and finishing. Operate rollers according to the manufacturer's recommendations. Compact the processed material full width by rolling from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

During compaction and final grading maintain the moisture content of the mixture to within 2 percent of optimum. Do not leave areas of stabilized material uncompacted or undisturbed for more than 30 minutes. Complete compaction within 1 hour after mixing.

Finish the compacted surface according to Subsection 301.06 to produce a surface that is smooth, dense, and free of compaction planes, ridges, or loose material. Clean the compacted surface of loose material, dirt, or other deleterious material by approved methods. Complete finishing operations within 4 hours from the start of mixing including corrections to irregularities in the surface.

305.11 Construction Joints. When cement application operations are delayed or stopped for more than 2 hours, make a transverse construction joint by cutting back into the completed work to form an approximately vertical face. Tie new work into the completed work by remixing approximately 36 inches (900 millimeters) of the completed course.

305.12 Curing. Cure the layer at least 1 day before placing the next course by one of the methods below:

(a) Water method. Keep the surface continuously moist by applying water through a spray bar equipped with nozzles producing a fine, uniform spray. During the first 24 hours of curing, use a water truck with side spray to avoid driving on the newly stabilized layer.

(b) Prime coat method. Seal the surface by placing an inverted prime coat according to Subsection 411.06(b). Provide and maintain a continuous film over the surface.

If approved by the CO, allow local automobile traffic on the cement stabilized layer 4 hours after finishing operations are complete. Limit traffic speeds to 20 miles (30 kilometers) per hour. Stop traffic if there is surface marring or deformation. Do not allow truck traffic (other than equipment necessary to complete the next course) on the cement stabilized layer until the next course is placed.

305.13 Maintenance. Maintain the cement stabilized layer to the correct line, grade, and cross-section until placement of the next course. If the cement stabilized layer loses stability, density, or finish before placement of the next course, reprocess, recompact, and add cement as necessary to restore the strength of the damaged material.

Overlay the stabilized base within 14 days after compacting.

305.14 Acceptance. See Table 305-2 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsection 106.03.

Cement will be evaluated under Subsections 106.02 and 106.03.

Construction of full depth reclamation with cement will be evaluated under Subsections 106.02 and 106.04.

Prime coat will be evaluated under Section 411.

Measurement

305.15 Measure the Section 305 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure crushed aggregate under Section 302.

Measure prime coat under Section 411.

Measure removal and disposal of unsuitable material under Section 203 or 204.

Payment

305.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 305 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 305-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Full depth reclamation (FDR) with cement mixture	Measured and tested for conformance (106.04)	All	–	Subsection 305.03	1 per submitted mix design	Existing roadway	Yes	Minimum 30 days before production	–
Production Start-up (control strip)									
FDR with cement material	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27	3 minimum	Behind reclaimer before compaction	No	Upon Completion of test	Minus 2-inch (50-mm) sieve requirement only
		Moisture-density (max density)	–	AASHTO T 134	1 minimum	"	Yes	"	Minimum 4 points per proctor
		Moisture content (in-place)	–	AASHTO T 255	3 minimum	In-place after compaction	No	"	–
		Density	–	AASHTO T 310 or other approved methods	Subsection 305.05(b)	"	"	"	–

Table 305-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
FDR with cement material	Measured and tested for conformance (106.04)	Moisture-density (maximum density)	–	AASHTO T 134	1 per change of material	Behind reclaimer before compaction	Yes	Before using in work	Minimum 4 points per proctor
		Density	–	AASHTO T 310 or other approved procedures	1 per 2,000 yd^2 (1,700 m^2)	In-place after compaction	No	End of shift	–
	Process control (153.03)	Gradation	–	AASHTO T 27	Minimum 1 per 3500 yd^2 (3000 m^2)	Behind reclaimer before compaction	"	Upon completion of test	Monitor percent passing the 2-inch (50-mm) and No. 4 (4.75 mm) sieves
		Moisture content (in-place)	–	AASHTO T 255 or other approved methods	"	In-place after compaction	"	"	–
		Unconfined compression strength (7-day)	–	Table 305-1	Minimum 1 per day	Behind reclaimer before compaction	"	7 days	7-day cure
Finished Product									
FDR with cement material	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Completed FDR surface	No	Before placement of next layer or as requested	–

Section 306. — FULL DEPTH RECLAMATION WITH ASPHALT

Description

306.01 This work consists of pulverizing an existing pavement and base in-place, adding crushed aggregate if required, mixing this material with emulsified asphalt or foamed asphalt and shaping and compacting the mix to produce a stabilized base. The mixture may also include cement or fly ash.

Emulsified asphalt grade is designated according to AASHTO M 140, AASHTO M 208, or Subsection 702.02.

Asphalt binder grade is designated according to AASHTO M 226 or AASHTO M 320.

Material

306.02 Conform to the following Section and Subsections:

Asphalt binder	702.01
Crushed aggregate	703.06
Emulsified asphalt	702.02
Fly ash, Class C	725.04(a)
Fog seal	406
Portland cement	701.01(a)
Water	725.01(c)

Construction Requirements

306.03 Proportioning. Collect representative samples of the pavement and aggregate base from the project. Replace removed pavement with asphalt concrete conforming to Subsection 403.02(b) or approved cold patch material.

Design a mix according to FLH T 522 conforming to the requirements of Table 306-1. When using foamed asphalt, supply a binder conforming to the requirements of Table 306-2. Submit the mix design and the following for approval 30 days before production:

(a) Optimum emulsified or foamed asphalt binder content based on total mass of mixture;

(b) Source and grade of emulsified or foamed asphalt binder;

(c) Optimum moisture content for compaction based on total mass of mixture;

(d) Recommended cement or fly ash content;

(e) Maximum wet and dry density for the mixture at the recommended proportions of binder, water, and cement or fly ash according to AASHTO T 180, Method D;

(f) Gradation and proportion of imported crushed aggregate;

(g) Results of tests and applicable graphs;

(h) A representative 350-pound (160-kilogram) sample of pavement, base, and imported crushed aggregate, if requested;

(i) Three 1-gallon (4 liter) samples of emulsified or asphalt binder, if requested;

(j) 15-pound (7-kilogram) sample of Portland cement or fly ash, if requested; and

(k) Optimum percent of injection water for foaming based on total mass of asphalt binder (when using foamed asphalt for the binder).

Begin production only after the mix design is approved. Submit a new mix design if there is a change in a material source.

Table 306-1
Asphalt Stabilized Base Course Mix Design Requirements

Binder type	Material or Property	Requirement
Emulsified asphalt and foamed asphalt	Indirect tensile strength, AASHTO T 283 (1)	
	Tensile strength wet	25 psi (170 kPa) minimum
	Tensile strength ratio (TSR)	60% minimum

(1) Follow the modified AASHTO T 283 procedures as indicated in FLH T 522.

Table 306-2
Foamed Asphalt Binder Property Requirements

Property	Requirement
Foamed asphalt expansion characteristics at 320, 338, & 356 °F (160, 170, & 180 °C)(1)	
Asphalt expansion ratio	10 minimum
Half-life of foamed expansion	6 seconds minimum

(1) See FLH T 522 for test procedures.

306.04 General. See Subsection 304.03.

306.05 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-stabilization preparatory phase meeting at least 7 days before the start of stabilizing operations according to Subsection 153.04(a).

(b) Control strip. Provide 7 days notice before beginning production.

On the first day of production, stabilize a 1000-foot (300-meter) long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using the construction procedures intended for the entire project. Cease production after construction of the control strip until the stabilized base layer and the control strip are evaluated and verified for approval.

After the reclaimer has pulverized and mixed one reclaimer width for 100 feet (30-meter) of the control strip and before compaction, dig a test pit to evaluate the mixing and distribution of the asphalt. If homogeneous mixing is not occurring, modify the process and pulverize, mix, and verify another 100 feet (30-meter). Continue until acceptable mixing and distribution of asphalt is obtained.

Take three random loose mix samples within the control strip and verify that 100 percent passes the 2-inch (50-millimeter) sieve.

Take nuclear gauge density readings behind each roller pass according to AASHTO T 310 to determine the roller pattern necessary to achieve at least 97 percent of the maximum wet density. Determine the maximum wet density by sampling processed material from behind the reclaimer (before compaction) and testing the material according to AASHTO T 180, Method D.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in unacceptable control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed base.

(c) Control strip verification. The control strip is verified when the specified density, gradation, and moisture content is obtained. Full production may begin once control strip is verified. Provide the CO with the reclaimer speed, emulsified or foamed asphalt application temperature, and asphalt and water line pressures used on the verified control strip.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the beginning of a new construction season.

306.06 Adding Crushed Aggregate. See Subsection 304.04.

306.07 Pulverizing and Mixing.

(a) When using emulsified or foamed asphalt furnish a road reclaimer that is:

(1) Self-propelled;

(2) Specifically manufactured for in-place reclamation;

(3) Capable of reducing the existing material to the required size;

(4) Equipped with at least an 8-foot (2.4-meter) cutting width;

(5) Equipped with standard automatic depth controls adjustable in increments of ½ inch (13 millimeters);

(6) Equipped with independent asphalt application nozzles capable of being turned off individually and verified open and working from within the operator cabin; and

(7) Equipped with an asphalt and water application control system including full width spray bars and positive displacement pumps automatically interlocked to the machine speed.

(b) In addition to the above, when using foamed asphalt furnish a road reclaimer that is:

(1) Equipped with an exterior test nozzle to verify proper foaming action;

(2) Equipped with individual expansion chambers for each nozzle where asphalt binder and water is injected under pressure through individual orifices for atomization and foam expansion;

(3) Equipped with an internal electric heat cleaning system to self-clean foaming nozzles;

(4) Equipped with maximum nozzle spacing of 6 inches (150 millimeters); and

(5) Equipped with a compressor capable of providing at least 45 pounds per square inch (310 kilopascals) of pressure.

Use the reclaimer to pulverize the existing roadway material in-place until 100 percent passes the 2-inch (50-millimeter) sieve. Reprocess or remove larger particles and dispose of them according to Subsection 203.05.

306.08 Applying Cement or Fly Ash. Do not apply cement or fly ash when conditions allow for excessive loss to blowing. Use a metered mechanical spreader to uniformly apply cement or fly ash on the roadway surface. Use canvas (or similar) skirts around the spreader box to minimize dust.

306.09 Applying Asphalt.

(a) Requirements for emulsified and foamed asphalt. Apply emulsified or foamed asphalt when the surface and air temperatures in the shade are at least 50 ºF (10 ºC). Do not begin applying emulsified asphalt during periods of fog, rain, or when temperatures below 35 °F (1.7 °C) are anticipated within 48 hours.

Automatically adjust the asphalt and water flow based the reclaimer speed and recycled material mass for the approved mix design. Maintain the asphalt temperature within the range recommended by the supplier.

Complete pulverizing and mixing operations in continuous one lane-width segments up to ½ mile (0.8 kilometers) in length. Mix the pulverized roadway material with emulsified asphalt binder, other additives, and the necessary mixing water for optimum dispersion. If two passes are used, shape and compact the reclaimed material with a steel drum roller after the first pass to provide depth control for the second pass of the reclaimer. Add the required quantity of emulsified or foamed asphalt during the final pass of the reclaimer.

Verify that the emulsified or foamed asphalt is evenly dispersed and coating the pulverized material. Dig test pits within the mix at least every ¼ mile (0.4 kilometers) and observe the distribution of the emulsified or foamed asphalt in each pit.

(b) Additional requirements for foamed asphalt. Do not use foamed asphalt with an application temperature below 320 °F (160 °C).

Do not apply foamed asphalt on previously treated foamed asphalt areas.

306.10 Compacting and Finishing. Compact and finish each segment before beginning mixing operations on the next segment. Maintain the moisture content of the mixture within 2 percent of optimum.

Compact the processed material uniformly to at least 97 percent of the maximum wet density as determined from the control strip. If material changes, reestablish the maximum wet density according to Subsection 306.05(b). Determine the in-place density according to AASHTO T 310.

Use at least three rollers: primary, secondary, and finish rollers sized and configured to achieve the required compaction and finish. Operate rollers according to the manufacturer's recommendations. Compact the processed material full width by rolling the material between the reclaimer wheel paths first then from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

Shape and grade the mixture to the correct lines, grades, and cross-section. Finish the compacted surface according to Subsection 301.06 to produce a surface that is smooth, dense, and free of compaction planes, ridges, or loose material. Clean the compacted surface of loose material, dirt, or other deleterious material by approved methods. Do not leave uncompleted segments at the end of the work day.

306.11 Construction Joints.

(a) Longitudinal joints. Make longitudinal joints coincide with each change in cross-slope, regardless of the overlap width. Provide a minimum longitudinal overlap of 6 inches (150 millimeters).

(b) Transverse joints. After full depth reclamation operations stop, ensure continuity across transverse joints by cutting back into the completed work for a distance recommended by the manufacturer of the reclaimer.

306.12 Curing and Maintenance.

(a) Emulsified asphalt. Keep traffic and equipment off the stabilized base for at least 1 hour after completing compaction. Do not allow traffic and construction equipment on the stabilized base until it is sufficiently stable to withstand marring and permanent deformation.

(b) Foamed asphalt. Before opening the stabilized base to traffic and after completing compaction, moisten the surface and roll with a pneumatic-tire roller to create a tight and closed surface. Continue to keep the surface moist until placement of the next course or final surface.

If required, place a fog seal on the surface of the stabilized base after final compaction according to Section 406.

Route hauling and other construction equipment uniformly over the full width of the recycled surface to minimize non-uniform compaction.

Maintain the emulsified asphalt stabilized layer to the correct line, grade, and cross-section until placement of the next course or final riding surface. If the stabilized layer loses stability, density, or finish before placement of the next course, reprocess and recompact as necessary to restore the strength of the damaged material.

Overlay the stabilized base material within 14 days after compacting.

306.13 Acceptance. See Table 306-3 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsection 106.03.

Cement or fly ash will be evaluated under Subsections 106.02 and 106.03.

Emulsified and foamed asphalt will be evaluated under Subsections 106.03, 106.04, and Table 306-1.

Blotter material will be evaluated under Subsection 106.03.

Construction of full depth reclamation with asphalt will be evaluated under Subsections 106.02 and 106.04.

Measurement

306.14 Measure the Section 306 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure crushed aggregate under Section 302.

Measure removal and disposal of unsuitable material under Sections 203 and 204.

Measure fog seal under Section 406.

Payment

306.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 306 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 306-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Emulsified asphalt	Measured and tested for conformance (106.04)	Quality	–	Subsection 702.02	1 per type & source of material	Asphalt supplier	Yes	Minimum 30 days before production	–
Asphalt binder (foamed)	"	"	–	Subsection 702.01 & Table 306-2	"	"	"	"	–
Mix Design									
Full depth reclamation (FDR) with asphalt mixture	Measured and tested for conformance (106.04)	All	–	Subsection 306.03 & FLH T 522	1 per submitted mix design	Existing roadway	Yes	Minimum 30 days before production	–

Table 306-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt binder (foamed)	Measured and tested for conformance (106.04)	Binder temperature	–	Subsection 306.09	1 minimum	Temperature gauge[3]	No	Upon completing test	–
		Half-life & expansion ratio	–	Table 306-2 & FLH T 522	"	Test nozzle on reclaimer	"	"	–
FDR with asphalt material	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27	3 minimum	Behind reclaimer before compaction	No	"	Minus 2-inch (50-mm) sieve requirement only
		Moisture-density (wet density)[1]	–	AASHTO T 180, Method D	1 minimum	"	"	"	–
		Moisture content (in-place)	–	AASHTO T 255	3 minimum	In-place after compaction	"	"	–
		Density	–	AASHTO T 310	"	In-place after compaction	"	"	Report wet density
	Visual inspection (106.02)	Homogeneous mixing	–	Subsection 306.05(b)	Subsection 306.05(b)	Behind reclaimer before compaction	"	"	–

Table 306-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
FDR asphalt material	Measured and tested for conformance (106.04)	Moisture-density (wet density)[1]	–	AASHTO T 180, Method D	1 per change in material	Behind reclaimer before compaction	No	Before using in work	–
		Density	–	AASHTO T 310	1 per 2000 yd^2 (1700 m^2)	In-place after compaction	"	End of shift	Report wet density
	Process control (153.03)	Gradation	–	AASHTO T 27	Minimum 1 per 3500 yd^2 (3000 m^2)	Behind reclaimer before compaction	No	Upon completion of test	–
		Moisture content	–	AASHTO T 255	1 per lane mile (lane kilometer)	"	"	"	–
		Homogeneous mixing	–	Subsection 306.05(b)	Minimum 1 per 3500 yd^2 (3000 m^2)	"	"	"	–
		Binder content of mix	–	Calculation (yield rate)	Minimum 1 per tank load	–	"	"	–
		Indirect tensile strength[2]	–	AASHTO T 283 (as modified by FLH T 522)	1 per 15000 yd^2 (12,540 m^2)	"	"	4 days	–

Table 306-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt binder (foamed)	Process control (153.03)	Binder temperature	–	Subsection 306.09	1 per tank load	Temperature gauge(3)	No	Upon completing test	–
		Half-life & expansion ratio	–	Table 306-2 & FLH T 522	"	Test nozzle on reclaimer	"	"	–
Finished Product									
FDR with asphalt material	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Completed FDR surface	No	Before placement of next layer or as requested	–

(1) At least 5 points per proctor.

(2) Immediately after collecting sample, transport to a field material laboratory and compact for indirect tensile strength testing.

(3) Measure asphalt binder temperature with a calibrated thermometer.

Section 307. — RESERVED

Section 308. — RESERVED

Section 309. — EMULSIFIED ASPHALT-TREATED BASE COURSE

Description

309.01 This work consists of constructing an emulsified asphalt-treated base course on a prepared surface.

Base aggregate grading is designated according to Table 703-2.

Material

309.02 Conform to the following Subsections:

Base course aggregate	703.05
Emulsified asphalt	702.02
Water	725.01(c)

Construction Requirements

309.03 General. Prepare the surface on which the emulsified asphalt-treated aggregate base course is placed according to Section 204 or 303 as applicable.

Submit at least 14 days before incorporating the aggregate into the work:

(a) A proposed target values within the gradation ranges shown in Table 703-2 for the required grading; and

(b) A representative 300-pound (150-kilogram) aggregate sample.

End placement and resubmit new target values if the calculated mean value for a tested sieve differs from the target value by more than the allowable deviation for that sieve.

309.04 Mixing and Spreading. Use a stationary pugmill with weighing, volumetric, or other gauging equipment capable of controlling the material entering the mixer. Interlock the controls for the aggregate feed with the emulsified asphalt and water controls to ensure uniform introduction of material into the mixer.

Determine the optimum moisture content of the mixture according to AASHTO T 180, Method D. Add aggregate and water to the mixer; then add 2 percent emulsified asphalt by mass of aggregate. Adjust the total liquid content (emulsified asphalt and water) to within 1 percent of the optimum moisture content at the time of compaction. Mix until particles are uniformly coated.

Place the treated aggregate after mixing. Spread the mixture on the prepared surface in a uniform layer. Shape the mixture to the required line, grade, and cross-section. Route hauling equipment uniformly over the full width of the surface to minimize rutting or uneven compaction.

309.05 Compacting. Compact the mixture according to Subsection 301.05.

309.06 Surface Tolerance. Finish the surface according to Subsection 301.06.

309.07 Maintenance. Maintain the emulsified asphalt-treated aggregate base course according to Subsection 301.07.

309.08 Acceptance. See Table 309-1 for sampling, testing, and acceptance requirements; including the category for quality characteristics.

Emulsified asphalt will be evaluated under Subsection 106.03.

Aggregate gradation, SE/P_{200} (SE/P_{75}) Index (SEP), and fractured faces will be evaluated under Subsection 106.05.

(a) Aggregate gradation. The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Table 703-2, except as follows:

(1) If the calculated mean value for a tested sieve exceeds the maximum gradation value shown in Table 703-2, the upper specification is equal to the maximum gradation value plus the allowable deviation, and the lower specification is equal to the maximum gradation value minus the allowable deviation.

(2) If the calculated mean value for a tested sieve is less than the minimum gradation value shown in Table 703-2, the upper specification is equal to the minimum gradation value plus the allowable deviation and the lower specification is equal to the minimum gradation value minus the allowable deviation.

(b) SEP. See Table 309-1, Note (2). The lower specification limit is 1.000.

(c) Fractured faces. The lower specification limit is 50 percent.

Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Construction of emulsified asphalt-treated base course will be evaluated under Subsections 106.02 and 106.04.

Measurement

309.09 Measure the Section 309 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring emulsified asphalt-treated aggregate base by the cubic yard (cubic meter), measure in the hauling vehicle.

When measuring emulsified asphalt-treated aggregate base by the square yard (square meter), measure the length horizontally along the centerline of the roadway. Measure the width horizontally to include the top of emulsified asphalt-treated aggregate base width and allowable widening.

Payment

309.10 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the Section 309 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 309-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (703.05)	Measured and tested for conformance (106.04 & 105)	LA abrasion (coarse)	–	AASHTO T 96	1 per rock type & not less than 5 per material source[(1)]	Source of material	Yes	Before using in work	Not required when using Government-provided sources
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	"
Aggregate base, Grading C, D, & E (703.05)	Process control (153.03)	Gradation	–	AASHTO T 11 & T27	Minimum 2 per day per stockpile	Crusher belt	No	24 hours	"
		Fractured faces	–	ASTM D5821	"	"	"	"	"

Table 309-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Aggregate base, Grading C, D, & E	Measured and tested for conformance (106.04)	Moisture-density (max density)	–	AASHTO T 180, Method D [3]	1 per type & source of material	Stockpile or Production output	Yes	Before using in work	–
Emulsified asphalt-treated aggregate base, Grading C, D, & E (703.05)	Statistical (106.05)	Gradation ⅜ inch (9.5 mm)	I	AASHTO T 30	1 per 1000 tons (900 metric tons)	In-place, after compaction	Yes	4 hours	–
		No. 4 (4.75 mm)	I						
		No. 40 (425 µm)	II						
		No. 200 (75 µm)	–						
		Fractured faces	I	ASTM D5821	"		"	"	–
		Sand equivalent		AASHTO T 176, Alternate Method No. 2, Reference Method	"	Belt feed before adding emulsified asphalt	"	"	–
		SEP	I	See Note (2)		–	No	–	–
Emulsified asphalt-treated aggregate base, Grading C, D, & E	Measured and tested for conformance (106.04)	Density	–	AASHTO T 310 or other approved procedures	1 per 500 tons (450 metric tons), but not less than 1 per layer	In-place, after compaction	No	Before placing next layer	–

Table 309-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Emulsified asphalt-treated aggregate base	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Completed base surface	No	Before placement of next layer or as requested	–

(1) Submit at least five reports, but not less than one report per rock type for each source. Submit reports dated within 1 year of intended use and include rock type and sample location. Obtain samples representative of aggregates being furnished.

(2) SEP (SE/P_{200} (SE/P_{75}) Index) is a measure of a material's ability to perform based on the quality and quantity of fines present. Quality is represented by the sand equivalent (SE) and quantity is represented by the percent passing the No. 200 (75-µm) sieve ($P_{200\,(75)}$). SEP is computed as follows:

For $SE \geq 29$, $SEP = SE/(P_{200\,(75)} + 25)$ and for $SE < 29$, $SEP = (SE + 4)/(SE + P_{200\,(75)})$.

Where: SE = Plastic fines in graded aggregates and soils by using the sand equivalent test. See AASHTO T 176, Alternate Method No.2, Reference Method.

$P_{200\,(75)}$ = Material finer than the No. 200 (75 µm) sieve in mineral aggregates by washing. See AASHTO T 11.

(3) At least 5 points per proctor.

Section 310. — COLD IN-PLACE RECYCLED ASPHALT BASE COURSE

Description

310.01 This work consists of milling an existing asphalt pavement, mixing the milled material with emulsified asphalt and lime, relaying the material in a one-pass operation, and compacting the material to produce a recycled asphalt base.

Cold in-place recycled asphalt base course compaction is designated Type A or B according to Subsection 310.09(b).

Emulsified asphalt grade is designated according to AASHTO M 140 or AASHTO M 208.

Material

310.02 Conform to the following Section and Subsections:

Emulsified asphalt	702.02
Fog seal	406
Lime	725.03(c)
Water	725.01(c)

Construction Requirements

310.03 Composition of Mix (JMF). Collect representative samples of the existing pavement to be milled. Replace removed pavement with asphalt concrete conforming to Subsection 403.02(b) or approved cold patch material.

Design a mix according to FLH T 524 and Table 310-1 mix design parameters. Submit the JMF and the following for approval 30 days before production:

(a) Optimum emulsified asphalt binder content based on total mass of mixture;

(b) Source and grade of emulsified asphalt binder;

(c) Optimum moisture content for dispersion and compaction based on total mass of mixture;

(d) Lime content;

(e) Maximum density for the mixture;

(f) Bulk specific gravity for the mixture;

(g) Results of tests and applicable charts and graphs;

(h) A representative 300-pound (135-kilogram) sample of pavement, if requested;

(i) Three, 1-gallon (4 liter) samples of emulsified asphalt binder, if requested; and

(j) 15-pound (7 kilogram) sample of lime, if requested.

Begin production only after the mix design is approved. Submit a new mix design if there is a change in a material source.

Table 310-1
Cold In-Place Recycled Asphalt Base Course Mix Design Parameter

Material or Property	Requirement
Indirect tensile strength, AASHTO T 283 (1)	
Tensile strength dry	70 psi (480 kPa) minimum
Tensile strength ratio (TSR)	70% minimum
Raveling test, ASTM D7196, 4 hour cure at 50 °F (10 °C), 50% humidity(2)	
Average mass loss	5% maximum

(1) Follow the modified AASHTO T 283 procedures as indicated in FLH T 524.

(2) Use the listed testing conditions for the raveling test, unless otherwise directed by the CO.

310.04 General. See Subsection 304.03.

Clear, grub, and remove vegetation and debris within 24 inches (600 millimeters) of the pavement to be recycled according to Section 201. Clean the pavement and edge of pavement of loose material, dirt, vegetation, and other deleterious material.

310.05 Equipment. Furnish a self-propelled recycling train with the following major units:

(a) Pavement milling machine. Provide the following:

(1) Automatic depth controls to maintain the cutting depth to within plus or minus ¼ inch (6 millimeters);

(2) Positive means cross slope elevation control;

(3) Capability of milling the existing asphalt pavement material to the required depth in a single path; and

(4) 12.5 feet (3.8 meters) minimum cutter width.

(b) Crushing unit. Capable of screening and crushing material to the required size before mixing with emulsified asphalt.

(c) Pugmill and proportioning equipment. Provide the following:

(1) Capable of continuously mixing the milled material with emulsified asphalt, water, lime, and other additives to produce a uniform and homogenous mixture;

(2) Belt scale for continuous weighing of milled and sized material with an interlocked computer controlled liquid metering device capable of automatically adjusting the flow of asphalt emulsion to the mass of milled material coming into the mixer;

(3) Proportioning equipment capable of applying emulsified asphalt and water to within plus or minus 0.2 percent of the required quantity by mass of milled material;

(4) Proportioning equipment with a digital meter for monitoring the flow rate and total milled material, emulsified asphalt, and water applied; and

(5) Capable of placing the mixture in a windrow without segregation.

(d) Paver. Provide a paver conforming to Subsection 401.05 that is capable of picking up the entire windrow and feeding it into the paver hopper. Do not heat the screed.

(e) Rollers. Provide double-drum steel wheel and pneumatic-tire rollers in sufficient quantity and size to obtain the required density. Provide pneumatic-tire rollers weighing a minimum 30 tons (27 metric tons).

310.06 Weather Limitations. Do not begin work when fog, showers, rain, frost, temperatures below 35 ºF (2 °C) are anticipated within 24 hours.

Place cold in-place recycled asphalt base on a dry, unfrozen surface when the air temperature in the shade and the road surface temperature are 50 ºF (10 °C) and rising.

310.07 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-recycling preparatory phase meeting at least 7 days before the start of recycling operations according to Subsection 153.04(a).

(b) Control strip. Provide 7 days notice before beginning production.

Construct the control strip on the project at an approved location. Recycle a 1500-foot (450-meter) long control strip, one-lane wide, and at the designated lift thickness. Use the construction procedures intended for the entire project. Cease production after construction of the control strip until the recycled base layer and the control strip are evaluated and verified for acceptance.

Acquire three random samples of milled material from the control strip after the material has passed through the crushing unit, but before emulsified asphalt is added for Type A compaction. Verify that 100 percent passes the 1½-inch (37.5-millimeter) sieve. Take density readings behind each roller pass to determine the roller pattern necessary to achieve the maximum in-place density (break point of compaction curve) according to ASTM D2950. Use the bulk specific gravity value from the mix design as a benchmark for evaluating the maximum in-place density achieved.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in unacceptable control strips. Accepted control strips may remain in place and will be measured as a part of the completed base course.

Full production may begin when a control strip is verified. Provide the CO with the maximum in-place density achieved (Type A compaction), application rates of the emulsified asphalt, water, and other additives used on the accepted control strip.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04 or the beginning of a new construction season.

310.08 Pavement Recycling and Mixing. Mill the existing pavement to the required depth and width. Reduce oversize particles to a maximum size of 1½ inch (37.5 millimeters).

When lime is required at the milling head or in the pugmill, incorporate lime slurry to within plus or minus 10 percent of the approved application rate. Produce the lime slurry using quicklime or hydrated lime and water in a slurry production unit equipped with scales and meters accurate to within 0.5 percent by mass. Agitate the transport and feed tanks to provide a consistent and pumpable lime slurry.

Combine milled material with emulsified asphalt, water, and lime at the approved application rates to produce a homogenous and uniformly-coated mixture. Maintain the emulsified asphalt temperature within the range recommended by the supplier.

Do not disturb underlying material. Synchronize the recycling rate to allow for continuous operation of recycling train equipment.

Continuously monitor and evaluate the milling, mixing, and placing operations to assure optimum quality of the recycled asphalt base course. Adjust application rates in coordination with the CO based upon material variations.

310.09 Spreading, Compacting, and Finishing.

(a) Spreading. Spread, and finish the recycled mix to the required line, grade, and elevation.

(b) Compacting. Begin compaction within 30 minutes of spreading. Use pneumatic-tire rollers until no displacement is observed. Use steel-wheel rollers, either in static or low-amplitude vibratory mode, to achieve final density and eliminate pneumatic-tire roller marks. Do not park or idle rollers on uncompacted material. Compact using the designated type:

(1) Type A compaction. Use roller patterns established during the control strip. Compact the recycled mix to obtain a minimum density of 97 percent of the control strip density. Measure in-place density according to ASTM D2950. If an area fails to meet required density, rework and recompact the area.

If applications rates of the emulsified asphalt from the approved mix design are changed by more than ±0.2 percent by mass of milled material, or if other material conditions distinctly change, reestablish roller pattern according to Subsection 310.07(b).

(2) Type B compaction. Compact the recycled mix using the following equipment, sequence, and number of roller passes:

(a) Four to six roller passes with a double drum, vibratory roller having a minimum mass of 5.5 tons (5 metric tons) and equipped with frequency and amplitude controls.

(b) Four to six roller passes with a pneumatic-tire roller having a minimum mass of 2000 pounds (910 kilograms) per wheel and a contact pressure of 80 pounds per square inch (550 kilopascals).

(c) Two to four roller passes with a static steel-wheel roller with a minimum pressure of 250 pounds per square inch (1730 kilopascals).

Compact the material with approved tampers or compactors along curbs, headers, walls, and places not accessible to the roller.

(c) Finishing. Produce a surface that is smooth, dense, and free of ruts, ridges, and loose material. Measure pavement surface according to Subsection 403.11, except defective areas are deviations between the surface and the bottom of the straightedge in excess of ⅜ inches (10 millimeters), measured between a two contacts of the straightedge, or at the end of the straightedge.

(d) Fog seal. Place a fog seal on the surface of the recycled asphalt base. Use emulsified asphalt diluted to 50 percent by volume with water and apply it at a rate of 0.05 to 0.15 gallons per square yard (0.25 to 0.70 liters per square meter). When necessary, place blotter according to Section 411.

310.10 Construction Joints.

(a) Longitudinal joints. Make longitudinal joints coincide with each change in cross-slope. Provide a minimum longitudinal overlap of 4 inches (100 millimeters).

(b) Transverse joints. At the beginning of each day's recycling operations or after extended work stoppages, ensure continuity across transverse joints by cutting back into the completed work for a distance recommended by the manufacturer of the cold recycling equipment.

310.11 Curing and Maintenance. Keep traffic and construction equipment off of the recycled asphalt base for at least 2 hours after completing compaction and until it is sufficiently stable to withstand raveling, marring, and permanent deformation. Route hauling and other construction equipment uniformly over the full width of the recycled asphalt base to minimize non-uniform compaction.

Maintain the recycled asphalt base to the correct line, grade, and cross-section. Provide additional rolling with a steel wheel roller to recompact and maintain a dense surface. Use a power broom to remove loose particles. If the recycled asphalt base loses stability, density, or finish, reprocess and recompact as necessary to restore the strength of the damaged material.

Place the next course or final surface when the moisture content of the recycled asphalt base is reduced to 2.5 percent or less according to AASHTO T 255, but within 14 days after recycling regardless of moisture content.

310.12 Acceptance. See Table 310-2 for sampling, testing, and acceptance requirements.

Emulsified asphalt binder will be evaluated under Subsections 106.03 and 106.04.

Lime will be evaluated under Subsections 106.02 and 106.03.

Blotter material will be evaluated under Subsection 106.03.

Construction of the cold in-place recycled asphalt base course will be evaluated under Subsections 106.02 and 106.04. Type A compaction will be evaluated under Subsection 106.04.

Pavement smoothness will be evaluated under Subsections 106.02 and 106.04.

Measurement

310.13 Measure the Section 310 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure fog seal under Section 406.

Payment

310.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 310 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 310-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Asphalt binder	Measured and tested for conformance (106.04)	Quality	–	AASHTO M 140, AASHTO M 208, & Subsection 702.02	1 per type and source of material	Asphalt supplier	Yes	Minimum 30 days before production	–
Design									
Emulsified asphalt mix design	Measured and tested for conformance (106.04)	All	–	Subsection 310.03 & FLH T 524	1 per submitted mix design	Existing roadway	Yes	Minimum 30 days before production	For Type A compaction only
Production Start-up (control strip)									
Emulsified asphalt mixture	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27	3 minimum	Before emulsion addition	No	Upon completing test	–
		Bulk specific gravity (density)	–	FLH T 524	1 minimum	Loose mix in windrow	"	”	For Type A compaction only
		Density	–	ASTM D2950 & Subsection 310.07(b)	Subsection 310.07(b)	In-place after compaction	"	"	"
		Depth of cut	–	–	3 minimum	Both ends of milling drum	"	"	–

Table 310-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Emulsified asphalt material	Measured and tested for conformance (106.04)	Bulk specific gravity (density)	–	FLH T 524	1 per change in material	Loose mix in windrow	No	Upon completion of test	For Type A compaction only
		Density	–	ASTM D2950 & Subsection 310.07(b)	1 per 2000 yd^2 (1700 m^2)	In-place after compaction	"	End of shift	"
		Depth of cut	–	–	1 per 500 ft (150 m)	Both ends of milling drum	"	"	–
	Process control (153.03)	Gradation	–	AASHTO T 27	Minimum 1 per 3500 yd^2 (3000 m^2)	Before emulsion addition	No	Upon completion of test	–
		Indirect tensile strength[(1)]	–	AASHTO T 283 (as modified by FLH T 524)	1 per 3500 yd^2 (3000 m^2)	"	"	4 days	"
Emulsified asphalt material	"	Application rates	–	Calculation of yield rate, Subsection 310.08	Minimum 1 per tank load	–	"	"	–

Table 310-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Cold recycled asphalt base	Measured and tested for conformance (106.04)	Surface tolerance	–	Straightedge measurement, Subsection 310.09(c)	Continuously, after compaction	Finished recycled base surface	No	24 hours	–

(1) Transport samples immediately to a field material laboratory for indirect tensile strength compaction. Compact within 1 hour of sampling.

Section 311. — STABILIZED AGGREGATE SURFACE COURSE

Description

311.01 This work consists of constructing a stabilized aggregate surface course with either imported or in-place aggregate.

Aggregate stabilization is designated as imported aggregate course or in-place aggregate course.

Aggregate grading is designated according to Table 703-3.

Material

311.02 Conform to the following Subsections:

Calcium chloride flakes	725.02(b)
Surface course aggregate (imported)	703.05
Water	725.01(c)

Construction Requirements

311.03 Proportioning. Determine the proportioning quantities of aggregate, calcium chloride flakes, and water required. Sample the imported aggregate or aggregate course before beginning stabilization operations. Determine the maximum density and optimum moisture content according AASHTO T 180, Method D. The CO will provide the target calcium chloride content by mass of the material at 95 percent of the maximum density. Set target water content at the time of mixing between 2 percent below optimum and optimum moisture content.

311.04 General. After a representative quantity of imported aggregate is produced, submit proposed target values for the appropriate sieve sizes to the CO. Set target values for the aggregate within the gradation ranges shown in Table 703-3. List the percent passing for sieve sizes shown in Table 703-3.

Store calcium chloride flakes in closed, weatherproof containers. Begin application or mixing operations only when the ambient air temperature is 40 °F (4 °C) or above, and is not expected to fall below 40 °F (4 °C) within 48 hours. Construct stabilized aggregate course when the underlying layer is dry and unfrozen.

(a) Imported aggregate course. Prepare the underlying surface according to Subsection 303.05.

(b) In-place aggregate course. Prepare the surface according to Subsection 303.06.

311.05 Mixing and Placing.

(a) In-place mixing. When imported aggregates are used, spread aggregate on the prepared surface in a uniform layer to the specified width.

For an imported or in-place aggregate course; maintain the quantities of calcium chloride and water content to within the following tolerances:

(1) Calcium chloride	±0.2 percent by total dry mass
(2) Water	±0.5 percent by total dry mass

Do not spread calcium chloride flakes in windy conditions that will result in loss of calcium chloride or dusting. Do not spread more calcium chloride flakes than can be incorporated within one hour.

Spread calcium chloride flakes uniformly across the prepared aggregate surface. Use distributor or rotary mixing equipment capable of metering and applying calcium chloride flakes and water uniformly across the full width of the surface to be mixed. For distribution equipment, verify the application rate by performing weight yield test panels for the first load of each distributor truck. For rotary mixing equipment, verify the application rate by calculating yields.

Mix the calcium chloride flakes into the aggregate course with rotary mixing equipment capable of uniformly mixing the material full depth in one pass.

Shape the aggregate course to the required cross-section after mixing is complete. Route hauling equipment uniformly over the full width of the aggregate surface to minimize rutting or uneven compaction.

(b) Pugmill mixing. Aggregates, calcium chloride flakes, and water may be mixed using a stationary pugmill with weighing or metering equipment capable of controlling the material entering the mixer. Interlock the metering controls for the aggregate feed with those of the calcium chloride flakes and water to ensure uniform introduction of material into the mixer. Maintain the quantities of aggregate, calcium chloride flakes, and water (based on the total dry mass) to within the following tolerances:

(1) Aggregate	±2.0 percent by total dry mass
(2) Calcium chloride	±0.2 percent by total dry mass
(3) Water	±0.5 percent by total dry mass

Haul and spread the material on the prepared surface in a uniform layer immediately after mixing. Maintain the moisture content from optimum to 2 percent below optimum while placing and spreading the mixture. Shape the aggregate course to the required cross-section. Route hauling equipment uniformly over the full width of the surface to minimize rutting or uneven compaction.

311.06 Compacting and Finishing. Compact the mixture according to Subsection 301.05.

Finish the aggregate course according to Subsection 301.06 and produce a surface free of loose material.

311.07 Acceptance. See Table 311-1 for sampling, testing, and acceptance requirements; including the acceptance quality characteristic category.

Calcium chloride flakes will be evaluated under Subsections 106.02 and 106.03.

Surface course aggregate (imported) will be evaluated for gradation, fractured faces, liquid limit, and plasticity index under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

(a) Aggregate gradation. The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Table 703-3, except as follows:

(1) If the calculated mean value for a tested sieve exceeds the maximum gradation value shown in Table 703-3, the upper specification is equal to the maximum gradation value plus the allowable deviation, and the lower specification is equal to the maximum gradation value minus the allowable deviation.

(2) If the calculated mean value for a tested sieve is less than the minimum gradation value shown in Table 703-3, the upper specification is equal to the minimum gradation value plus the allowable deviation and the lower specification is equal to the minimum gradation value minus the allowable deviation.

(b) Fractured faces. When aggregate is produced from a gravel source, use the specification limit shown in Subsection 703.05(a)(5).

(c) Liquid limit index. The specification limit is shown in Subsection 703.05(c)(2).

(d) Plasticity liquid limit. The specification limit is shown in Subsection 703.05(c)(3).

Construction of aggregate stabilization courses will be evaluated under Subsections 106.02 and 106.04.

Reconditioning of the aggregate course for in-place aggregate will be evaluated under Section 303.

Preparation of the surface on which the treated imported aggregate course is placed will be evaluated under Section 303.

Measurement

311.08 Measure the Section 311 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring surface course aggregate stabilization by the square yard (square meter), measure the length horizontally along the centerline of the roadway. Measure width horizontally to include the top of subgrade width and allowable widening.

Payment

311.09 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the Section 311 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 311-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source (Imported Aggregate Only)									
Imported aggregate source quality (703.05(a))	Measured and tested for conformance (106.04 & 105)	LA abrasion (coarse)	–	AASHTO T 96	1 per type & not less than 5 per source of material[(2)]	Source of material	Yes	Before using in work	Not required when using Government-provided sources
		Soundness using sodium sulfate (course & fine)	–	AASHTO T 104	"	"	"	"	"
Imported aggregate (703.05)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile, min	Crusher belt	No	24 hours	"
		Fractured faces	–	ASTM D5821	"	"	"	"	"
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	Crusher belt or after processing	"	"	–
		Plasticity index	–	AASHTO R 58, T 89 & T 90	"	"	"	"	"
Proportioning									
Proportioning (311.03)	Measured and tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D[(1)]	1 per mixture or change in material	Processed material before incorporating in work	Yes	Before using in work	Report proportion of aggregate, calcium chloride, & water

Table 311-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
In-place aggregate (311.03)	Measured and tested for conformance (106.04)	Moisture-density (proportioning)	–	AASHTO T 180, Method D[(1)]	1 per 2500 feet (760 meters) or a minimum of 3 samples	Processed material before incorporating in work	Yes	Before using in work	When incorporating existing aggregate
Imported aggregate (703.05)	Statistical (106.05)	Gradation		AASHTO T 27 & T 11	1 per 1000 tons (900 metric tons)	Processed aggregate before stabilizing	Yes	4 hours	When using imported aggregate
		No. 4 (4.75 mm)	I						
		No. 40 (425 µm)	I						
		No. 200 (75 µm)	II						
		Other specified sieves	II						
		Liquid limit	II	AASHTO R 58 & T 89, Method A	"	"	"	"	–
		Fractured faces	II	ASTM D5821	"	"	"	"	"
		Plasticity index	II	AASHTO R 58, T 89, & T 90	"	"	"	"	"

Table 311-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Surface course aggregate stabilization	Measured and tested for conformance (106.04)	Density & moisture content	–	AASHTO T 310 or other approved procedures	1 per 500 tons (450 metric tons) or 3000 yd^2 (2500 m^2)	In-place, after compaction	No	End of shift	–
Finished Product									
Surface course aggregate stabilization	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Finished surface course	No	As requested	–

(1) Minimum of 5 points per proctor.

(2) Furnish at least five reports, but not less than one report per rock type for each source. Reports must be dated within 1 year of intended use. Obtain samples representative of aggregates being furnished. Include rock type and sample location on test reports.

Section 312. — DUST PALLIATIVE

Description

312.01 This work consists of furnishing and applying one or more applications of dust palliative on a prepared surface.

The application method is designated according to Subsection 312.04.

Material

312.02 Conform to the following Subsections:

Calcium chloride, magnesium chloride, and lignosulfonate	725.02
Water	725.01(c)

Construction Requirements

312.03 General. Furnish equipment for spreading and processing dust palliative. Make the equipment available for inspection and approval before use. Do not apply dust palliative when raining, rain is anticipated within 24 hours of application, or when the ground is frozen. Apply when the ambient air temperature is 40 °F (4 °C) or above.

Protect structures and trees from splatter or marring. Use multiple applications at a reduced rate if necessary to prevent runoff. Prevent discharge of dust palliative into waters of the United States as defined by the Clean Water Act.

312.04 Surface Preparation and Application.

(a) Method 1. Single application. Blade and shape the roadbed. Leave 1 to 2 inches (25 to 50 millimeters) of loose material on the surface. Water the loose material so it is visibly moist. Thoroughly mix the moist loose material.

Apply water, calcium chloride, magnesium chloride, or lignosulfonate liquid at a rate of 0.25 to 0.50 gallons per square yard (1.00 to 2.25 liters per square meter) as approved by the CO. Apply calcium chloride flakes at the rate of 1.0 to 2.0 pounds per square yard (0.5 to 1.0 kilograms per square meter) as approved by the CO. Process the dust palliative uniformly throughout the loose material. Moisten the mixture as necessary and compact by operating rollers over the full width of each layer until visual displacement ceases.

(b) Method 2. Two applications of calcium chloride or magnesium chloride liquid.

(1) First application. Scarify, blade, and shape the roadbed. Leave 3 inches (75 millimeters) of loose material on the surface. Water the loose material so it is visibly moist. Thoroughly mix the moist loose material.

Apply calcium chloride or magnesium chloride liquid solutions with a distributor at a rate of 0.50 to 1.0 gallons per square yard (2.25 to 4.50 liters per square meter) as approved by the CO. Use a tractor rotary tiller, or other approved mixing device, immediately behind the distributor to incorporate the water solution into the full width of loose material. Shape the surface to line and grade and compact according to Subsection 204.11(a).

Allow at least one week of curing time between the first and second applications.

(2) Second application. Apply calcium chloride or magnesium chloride liquid to the finished surface at a maximum rate of 0.20 gallons per square yard (0.9 liters per square meter) as approved by the CO.

312.05 Opening to Traffic. Keep traffic off the treated surface until the dust palliative has penetrated and cured to prevent excessive pickup under traffic.

312.06 Acceptance. Dust palliative material (calcium chloride liquid, calcium chloride flake, magnesium chloride liquid, and lignosulfonate liquid) will be evaluated under Subsection 106.03. Provide a commercial certification that includes the date, identification number (truck or trailer), net mass, and brand name with each shipment. For liquid dust palliatives provide the net volume and specific gravity at 60 °F (15 °C), percent solids by mass, and pH. For solid dust palliatives provide the concentration of the product.

Application of dust palliative will be evaluated under Subsections 106.02 and 106.04.

Measurement

312.07 Measure the Section 312 pay items listed in the bid schedule according to Subsection 109.02.

Payment

312.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 312 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 313. — AGGREGATE-TOPSOIL COURSE

Description

313.01 This work consists of furnishing and placing an aggregate, topsoil, and seed mixture on a prepared shoulder or other surface.

Material

313.02 Conform to the following Subsections:

Aggregate for aggregate-topsoil course	703.13
Seed	713.04
Topsoil	713.01
Water	725.01(c)

Construction Requirements

313.03 Preparing Surface. Complete the adjoining pavement before placing an aggregate-topsoil course on the shoulder. Scarify the area where the mixture is to be placed to a depth of 3 inches (75 millimeters). Reduce clods and sod to a maximum size of 4 inches (100 millimeters).

313.04 Mixing, Placing, and Compacting. Furnish a mixture of 50±10 percent aggregate and 50±10 percent topsoil by volume with sufficient water for compaction.

Mix the components into a uniform mixture. Spread the mixture on the prepared surface in a uniform layer. Shape the mixture to the line, grade, and cross-section. Remove clods and stones greater than 2 inches (50 millimeters) in diameter. Before compaction, dry seed the mixture surface at a rate of 75 pounds per acre (85 kilograms per hectare) according to Section 625.

Uniformly compact the mixture to ensure it does not exhibit heaving, pumping, rutting, or shearing. After compaction, dry seed the surface again at a rate of 75 pounds per acre (85 kilograms per hectare).

313.05 Acceptance. Aggregate for aggregate-topsoil will be evaluated under Subsections 106.02 and 106.03.

Seed and topsoil will be evaluated under Subsections 106.02 and 106.03.

Construction of aggregate-topsoil course will be evaluated under Subsection 106.02.

Measurement

313.06 Measure the Section 313 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring aggregate-topsoil course by the cubic yard (cubic meter), measure in the hauling vehicle.

Payment

313.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 313 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 314. — STOCKPILED AGGREGATES

Description

314.01 This work consists of furnishing and placing material in a stockpile for future use by the Government.

Aggregate grading is designated according to the applicable tables of Section 703.

Material

314.02 Conform to the following Section:

Aggregate	703

Construction Requirements

314.03 General. Conform to the gradation and quality requirements specified in the Section identified for the material.

After a representative quantity of aggregate is produced, submit proposed target values for the appropriate sieve sizes along with a representative sample size as specified in the Section identified for the material.

Set target values within the gradation ranges shown in the applicable table for the required grading.

314.04 Stockpile Site. The Government will acquire the permits and rights to stockpile aggregate from sources identified in the contract if the material is stockpiled for future use.

Prepare a plan of operation. Do not perform work within a Government-provided source until a plan of operation for the development of the source is accepted.

Obtain CO approval before preparing sites. Prepare sites as necessary to accommodate the quantity of material to be stockpiled in a manner that prevents contamination of the stockpiles.

Prepare new sites as follows:

(a) Clear and grub according to Section 201;

(b) Grade, shape, and compact the site to a uniform cross-section that drains; and

(c) Place, compact, and maintain a minimum 6-inch (150-millimeter) layer of crushed aggregate over the stockpile site and access roads for stabilization.

Obtain CO approval before stockpiling aggregates.

314.05 Stockpile. Build aggregate stockpiles in layers not to exceed 36 inches (900 millimeters) in thickness. Make the side slopes of each layer no flatter than 1V:1.5H. Spread aggregates with trucks or other approved pneumatic-tire equipment. Complete each layer before depositing aggregates on the next layer. Do not allow aggregates from the layer being built to run down over lower layers. Do not drop aggregates from a bucket or spout in one location to form a cone-shaped pile. Do not push aggregates into piles. Make the stockpiles neat and regular in shape.

Use plank runways or other suitable methods to avoid tracking dirt or other foreign matter onto the stockpiled material when operating trucks on stockpiles.

Space stockpiles far enough apart or install partitions to prevent the mixing of aggregate gradations.

Protect stockpiles for future use with an approved cover.

314.06 Acceptance. See the table for sampling, testing, and the acceptance requirements; including the category for quality characteristics specified in the Section identified for the material. The point of sampling and testing for aggregate stockpiled for future use is in the stockpile.

Subbase, base, surface course, chip seal aggregate gradations, and surface course plasticity index will be evaluated under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Preparation of stockpile sites and construction of stockpiles will be evaluated under Subsections 106.02 and 106.04.

Clearing and grubbing will be evaluated under Section 201.

Measurement

314.07 Measure the Section 314 pay items listed in the bid schedule according to Subsection 109.02.

Payment

314.08 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 400
ASPHALT PAVEMENTS AND SURFACE TREATMENTS

Section 401. — ASPHALT CONCRETE PAVEMENT BY GYRATORY MIX DESIGN METHOD

Description

401.01 This work consists of constructing one or more courses of asphalt concrete pavement using hot or warm mix asphalt (HMA or WMA).

Asphalt concrete pavement nominal maximum size aggregate size is designated according to Tables 401-1 and 703-5. Equivalent single axle loads (ESAL) or number of gyrations at design (N_{Design}) is designated according to Tables 401-1.

Pavement roughness type is designated according to Subsection 401.16. When no roughness type is designated use Type IV.

Asphalt binder is designated according to AASHTO M 320.

Antistrip additive type is designated according to Subsection 702.05. When no type is designated use Type 3 (lime).

Material

401.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Asphalt concrete aggregate	703.07
Mineral filler	725.05

Construction Requirements

401.03 Composition of Mix (JMF). Provide asphalt concrete mixes of aggregate, asphalt binder, recycled asphalt pavement (RAP), and additives that meet the applicable material requirements and the appropriate design parameters in Table 401-1 and are capable of being placed and compacted as specified. Volumetric mix properties will be determined at N_{design} according to AASHTO T 312 and AASHTO R 35.

Apply asphalt concrete mix design requirements for HMA to the development of the WMA mix design. Provide modifications to the process required for WMA technology. Submit modifications to the asphalt concrete mix design process according to Appendix X.2 of AASHTO R 35, *Special Mix Design Considerations and Practices for Warm Mix Asphalt (WMA)* for approval by the CO.

(a) RAP. Limit the quantity of RAP by mass in the JMF to 20 percent.

(b) Baghouse fines. If used, document how baghouse fines are reintroduced and measured. Submit target values for the percent of baghouse fines reintroduced to the JMF if they are a separate stockpile.

Table 401-1
Gyratory Asphalt Concrete Mix Design Requirements, AASHTO R 35

Design ESAL (Million)	Gyratory Compaction Level (% Theoretical Maximum Specific Gravity, G_{mm}) AASHTO T 312			Minimum Voids-in-the Mineral Aggregate (VMA), % (1)					Voids Filled with Asphalt (VFA), %	Dust-to-Binder Ratio (3)	Minimum Tensile Strength Ratio, AASHTO T 283
				Nominal Maximum Size Aggregate (2)							
	$N_{initial}$	N_{design}	N_{max}	1 inch (25 mm)	¾ inch (19 mm)	½ inch (12.5 mm)	⅜ inch (9.5 mm)	#4 sieve (4.75 mm)			
< 0.3	6 (≤91.5%)	50 (96.0%)	75 (≤98.0%)	12.0-15.0	13.0-16.0	14.0-17.0	15.0-18.0	–	70.0 - 80.0	0.8 -1.6	0.80
0.3 to < 3	7 (≤90.5%)	75 (96.0%)	115 (≤98.0%)						65.0 - 78.0		
3 to 30	8 (≤89.0%)	100 (96.0%)	160 (≤98.0%)						65.0 - 78.0		
–	6 (≤91.5%)	50 (96.0%)	75 (≤98.0%)	–	–	–	–	16.0 - 19.0	76.0 - 80.0	0.6 - 2.0	

(1) When mineral filler or hydrated lime is used, include in the calculation for compliance with the VMA.

(2) The nominal maximum size aggregate is one size greater than the first sieve to retain more than 10 percent of the combined aggregate.

(3) Dust to binder ratio is the effective asphalt content divided by the total percent of material passing the No. 200 (75-µm) sieve. Dust includes lime, bag house fines, and other mineral matter.

(c) Submission. Submit written JMFs and associated material with FHWA Form 1641, *Worksheet for Superpave Asphalt Concrete Mix Design* for verification at least 30 days before the control strip. Include a signed statement prepared by the testing laboratory that certifies the proposed JMF meets requirements and can be compacted in the field during production. For each proposed JMF, submit the following:

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each specified sieve size for the aggregate blend; and

(2) Designate target values within the gradation band specified for the nominal maximum size aggregate grading shown in Table 703-5;

(b) Source and percentage of each stockpile to be used;

(c) Average gradation of each stockpile;

(d) Representative samples from each stockpile. Use split samples of material taken at the same time samples are taken for testing by the Contractor's laboratory.

(1) 600 pounds (270 kilograms) of aggregates proportioned by each stockpile according to the JMF; and

(2) 10 pounds (4.5 kilograms) of mineral filler, if proposed for the JMF; and

(e) Results of aggregate quality tests performed within 1 year of use. For aggregate quality tests, see Subsection 703.07.

(2) Asphalt binder.

(a) Target asphalt binder content;

(b) Five 1-gallon (4-liter) samples of the asphalt binder;

(c) Test results from the manufacturer according to AASHTO M 320 for the asphalt binder including a temperature-viscosity curve; and

(d) Mixing temperature range and minimum compaction temperature for the asphalt binder.

(3) Antistrip additives. If part of the JMF:

(a) 1 pint (0.5 liter) of liquid antistrip additive or 2 pounds (0.9 kilograms) of cement or lime antistrip additive;

(b) Name of product;

(c) Manufacturer; and

(d) Manufacturer's MSDS and product data sheets.

(4) RAP. If part of the JMF:

(a) Source and percentage of RAP;

(b) Gradation of the RAP;

(c) Effective specific gravities of each stockpile;

(d) Percent asphalt binder in RAP by total mass according to AASHTO T 308; and

(e) 100-pound (45-kilogram) representative sample of each RAP stockpile.

(5) WMA technology and additive information.

(a) 1-gallon (4-liter) WMA additive sample with method for incorporating it in the asphalt concrete mix design process;

(b) WMA manufacturer's usage recommendations including additive target rates;

(c) Documentation of past WMA technology field applications including project type, project owner, tonnage placed, asphalt concrete mix design, mixture volumetrics, and performance;

(d) Laboratory mixing and compacting temperature;

(e) Asphalt binder performance grade test data over the range of WMA additive percentages proposed for use if applicable;

(f) Compatibility of WMA additive with asphalt binder and antistrip additive; and

(g) Temperature range for field asphalt concrete mix production, delivery, lay-down and compaction.

(d) Verification. The verification process starts when required documentation and material are received. When the JMF is verified, begin asphalt concrete mix production for the control strip.

(1) Aggregate gradations. The Contractor's aggregate gradation is verified if the CO's gradation on a combined asphalt concrete mix using the Contractor's aggregate and RAP stockpile percentage recommendations is within the Contractor's target value gradation plus or minus the following tolerance for each sieve:

Sieve Size	Tolerance, %
1 inch (25 mm)	±3.0
¾ inch (19 mm)	±3.0
½ inch (12.5 mm)	±3.0
⅜ inch (9.5 mm)	±3.0
No. 4 (4.75 mm)	±3.0
No. 8 (2.36 mm)	±3.0
No. 30 (600 µm)	±2.0
No. 50 (300 µm)	±2.0
No. 200 (75 µm)	±1.0

(2) RAP asphalt binder content and gradation. The Contractor's RAP asphalt binder content results are verified if the CO's result for each stockpile is within ±0.75 percent by total mass using AASHTO T 308. Submit the RAP dry gradation, burned gradation, asphalt content, and specific gravity information as shown on the RAP data sheet of FHWA Form 1641.

(3) Bulk specific gravity of aggregate (G_{sb}). The Contractor's coarse and fine G_{sb} is verified if the CO's results are within 0.013 for AASHTO T 85 and 0.030 for AASHTO T 84.

(4) Voids in the mineral aggregate (VMA). The Contractor's VMA result is verified if the CO's result is above the minimum specification limit in Table 401-1.

(5) Voids filled with asphalt (VFA). The Contractor's VFA result is verified if the CO's result is within the specification limit in Table 401-1.

(6) Air voids (V_a). The Contractor's V_a result is verified if the CO's result at the same design asphalt binder content is between 3.0 and 5.0 percent.

(7) Tensile strength ratio (TSR). The Contractor's TSR result is verified if the CO's result is above the minimum specification limit in Table 401-1.

(e) Changes and resubmissions. If a JMF is rejected or the source of material is changed, submit a new JMF for verification. Up to 30 days may be required to evaluate a change after receipt of required documentation and material. Approved changes in target values will not be applied retroactively for payment.

The CO will deduct JMF evaluation costs resulting from the following:

(1) Contractor-requested changes to the approved JMF;

(2) Contractor requests for more than one JMF evaluation; and

(3) Additional testing necessary due to the failure of a submitted JMF.

401.04 Mixing Plant. Use mixing plants conforming to AASHTO M 156.

(a) Drum dryer-mixer plants.

(1) Bins. Provide a separate bin in the cold aggregate feeder for each individual aggregate stockpile in the asphalt concrete mix. Use bins of sufficient size to keep the plant in continuous operation and of proper design to prevent overflow of material from one bin to another.

(2) Stockpiling procedures. Separate aggregate into at least three stockpiles with different gradations.

(b) Batch plants.

(1) Hot aggregate bin. Provide a bin with three or more separate compartments for storage of the screened aggregate fractions to be combined for the asphalt concrete mix. Make the partitions between the compartments tight and of sufficient height to prevent spillage of aggregate from one compartment into another.

(2) Load cells. Calibrated load cells may be used in batch plants instead of scales.

(3) RAP. Modify batch plants so RAP is introduced into the asphalt concrete mix after bypassing the dryer. Design the cold feed bin, conveyor system, and special bin adjacent to the weigh hopper, if used, to avoid segregation and sticking of the recycled asphalt pavement material. Heat aggregate to a temperature that will transfer sufficient heat to the recycled asphalt pavement material to produce an asphalt concrete mix of uniform temperature within the range specified in the approved JMF.

(c) WMA plant modifications.

(1) Modify the mixing plant as required by the manufacturer to introduce the WMA technology. Interlock the WMA additive delivery system with the automated proportioning system;

(2) Comply with manufacturer's recommendations for incorporating additives and WMA technologies into the asphalt concrete mix. Comply with manufacturer's recommendations regarding delivery and storage of additives; and

(3) Modify the plant burner and drum flights to operate at lower production temperatures.

401.05 Equipment.

(a) Pavers. Furnish pavers that are:

(1) Self-contained, power-propelled units with adjustable vibratory screeds with full-width screw augers;

(2) Heated for the full width of the screed;

(3) Capable of spreading and finishing courses of asphalt concrete mix in widths at least 12 inches (300 millimeters) more than the width of one lane;

(4) Equipped with a receiving hopper having sufficient capacity to ensure a uniform spreading operation;

(5) Equipped with automatic feed controls, which are properly adjusted to maintain a uniform depth of material ahead of the screed;

(6) Operable at forward speeds consistent with satisfactory asphalt concrete mix lay down;

(7) Capable of producing a smooth-finished surface without segregating, tearing, shoving, or gouging;

(8) Equipped with automatic screed controls with sensors capable of sensing grade from an outside reference line, sensing the transverse slope of the screed, and providing the automatic signals that operate the screed to maintain grade and transverse slope; and

(9) Equipped with a screed mounted safety edge device capable of:

(a) Maintaining contact with the road shoulder surface;

(b) Allowing automatic transition to cross roads, driveways, and obstructions; and

(c) Constraining and reducing the volume of the asphalt concrete material head to increase the density of the extruded profile.

Do not use conventional single plate strike off.

(b) Material transfer vehicle (MTV). When required, furnish an MTV with the following:

(1) A loading system with the ability to receive mixtures from the hauling equipment;

(2) A minimum storage capacity of 13 tons (11.8 metric tons) with a remixing system in the MTV storage bin;

(3) A discharge conveyor to deliver the mixture to the paver hopper; and

(4) A mass not exceeding the maximum legal loadings on structures.

Pick-up machines, hopper inserts, and material transfer devices are not considered MTVs.

401.06 Surface Preparation. Clean the existing surface of loose material, dirt, or other deleterious material by approved methods. Apply an asphalt tack coat to contact surfaces of pavements, curbs, gutters, manholes, and other structures according to Section 412.

401.07 Weather Limitations. Place asphalt concrete mix on a dry, unfrozen surface when the air temperature in the shade is above 35 °F (1.7 °C) and rising. For HMA, conform to Table 401-2.

Table 401-2
Asphalt Concrete Mix Placement Temperature

Compacted Lift Thickness →	**< 2 Inches (< 50 mm)**	**2 – 3 Inches (50 – 75 mm)**	**> 3 Inches (> 75 mm)**
Road Surface Temperature °F (°C)	**Minimum Lay-Down Temperature[1] °F (°C)**		
< 35 (1.7)	[2]	[2]	[2]
35 – 39.9 (1.7 – 4.3)	[2]	[2]	280 (138)
40 – 49.9 (4.4 – 9.9)	[2]	285 (141)	275 (135)
50 – 59.9 (10.0 – 15.5)	295 (146)	280 (138)	270 (132)
60 – 69.9 (15.6 – 21.1)	285 (141)	275 (135)	265 (129)
70 – 79.9 (21.2 – 26.6)	280 (138)	270 (132)	265 (129)
80 – 89.9 (26.7 – 32.2)	270 (132)	265 (129)	260 (127)
≥ 90 (32.2)	265 (129)	260 (127)	255 (124)

(1) Do not heat the asphalt concrete mix above the temperature specified in the approved asphalt concrete mix design.

(2) Do not pave.

401.08 Asphalt Preparation. Uniformly heat the asphalt binder to provide a continuous supply of heated asphalt binder from storage to the mixer. Do not heat asphalt binder above 365 °F (185 °C).

If a liquid heat stable antistrip additive is used, meter it into the asphalt binder transfer lines at a bulk terminal or mixing plant. Inject the additive for at least 80 percent of the transfer or mixing time to obtain uniformity.

401.09 Aggregate Preparation. When lime is used as an antistrip, adjust the aggregate moisture to at least 4 percent by mass of aggregate. Mix the lime uniformly with the aggregate before introducing the aggregate into the dryer or dryer drum. Use calibrated weighing or metering devices to measure the quantity of lime added to the aggregate.

For batch plants, heat, dry, and deliver aggregate for pugmill mixing at a temperature sufficient to produce an asphalt concrete mix temperature within the approved range. Adjust flames used for drying and heating to prevent damage to and contamination of the aggregate. Additional plant adjustments may be required to provide dry aggregate at the reduced mixing temperatures of WMA.

Control plant operations so the moisture content of the asphalt concrete mix behind the paver is 0.5 percent or less according to AASHTO T 329.

Before starting asphalt concrete mix production, obtain approval of synchronized metering and weighing devices used to introduce a constant rate of lime and water.

Add lime to the aggregate by one of the following methods:

(a) Method A. Add lime to the combined cold feed aggregate using an enclosed in-line cold feed mechanical pugmill mixer. Use a twin-shaft, continuous mixing pugmill with adjustable mixing paddles. Adjust the retention time of the mixture in the pugmill so no unmixed lime is visible after the lime and aggregate exit the pugmill.

(b) Method B. Add lime to the produced aggregates during stockpiling using a pugmill. Distribute the lime per the stockpile ratios stated in the asphalt concrete mix design.

A minimum moisture content of 2 percent by dry weight for coarse aggregate and 4 percent by dry weight for fine aggregate is required at the time the aggregates and lime are mixed. Marinate treated aggregate in stockpiles from 24 hours to 60 days before using in asphalt concrete mix. Do not use aggregate marinated longer than 60 days.

(c) Method C. Add lime to the combined cold feed aggregate by introducing the lime between aggregate layers as the aggregate flows from the cold feed bins. Mix the lime and aggregate on the conveyor belt by placing at least of six paddles over the conveyor belt. Make the paddles protrude into the aggregate flow and direct the aggregate to fold over itself causing the material to migrate from one side of the conveyor belt to the other. Space the paddles to provide complete mixing. Provide a water spray over the conveyor belt as necessary to control dust and to maintain minimum moisture content.

401.10 Mixing. Measure the aggregate and asphalt into the mixer according to the JMF. Mix until particles are completely and uniformly coated with asphalt according to AASHTO M 156. Maintain the discharge temperature according to the JMF.

401.11 Hauling. Use vehicles with tight, clean, and smooth metal beds for hauling asphalt concrete mixes.

Coat the beds with an approved material to prevent the asphalt concrete mix from adhering to the beds. Do not use petroleum derivatives or other coating material that contaminates or alters the characteristics of the mix. Drain the bed before loading.

Equip each truck with a canvas cover or other suitable material of sufficient size to protect the asphalt concrete mix from the weather. When necessary to maintain temperature, use insulated truck beds and securely fastened covers. Provide access ports or holes for checking temperature of asphalt concrete mix in the truck.

401.12 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-paving preparatory phase meeting at least 3 days before the start of paving operations according to Subsection 153.04(a). In addition, be prepared to discuss the following:

(1) Calibration certification for the gyratory compactor; and

(2) Asphalt and aggregate correction factors according to AASHTO T 308 and AASHTO T 30 on FHWA Form 1640, *Worksheet for Ignition Furnace Binder Correction Factor AASHTO T 308*. If RAP is included as part of the JMF, provide the asphalt and aggregate correction factors according to AASHTO T 30 and the FLH Addendum to AASHTO T 308 on FHWA Form 1648, *Worksheet For Ignition Furnace Binder Correction Factor And Aggregate Gradation Correction Factor For Mixes Including Rap*.

(b) Control strip. Provide 7 days notice before beginning production of an asphalt concrete mix.

On the first day of production, produce sufficient asphalt concrete mix to construct a 1000-foot (300-meter) long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using asphalt concrete mix production, lay-down, and compaction procedures intended for the entire mix. Cease production after construction of the control strip until the asphalt concrete mix and the control strip are evaluated for acceptance.

(1) Mixture. Take and test at least three control strip asphalt concrete mix samples and evaluate according to Subsection 401.17. The asphalt concrete mix is acceptable if all test results are within specification limits for asphalt content and VMA; and the calculated pay factor for asphalt content, VMA, and gradation is 0.90 or greater.

(2) Compaction. Compact according to Subsection 401.14. Take nuclear gauge density readings behind each roller pass to determine the roller pattern necessary to achieve required density.

Take nuclear gauge density readings and cut and test core samples according to Table 401-8. Density is acceptable if the core density pay factor is 0.90 or greater. Furnish the CO with documented nuclear gauge readings correlated to core specific gravities.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in unacceptable control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed pavement. Tests used for the control strip will not be included in the evaluation for payment according to Subsection 106.05. When a control strip is verified and accepted, full production may begin.

Use these start-up procedures when producing material from a different plant or when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.05.

401.13 Placing and Finishing. Do not use mixes produced from different plants unless the mixes are produced according to the same JMF, use material from the same sources, and are approved. Construct control strips according to Subsection 401.12 for each plant from which production is intended.

Place HMA at a temperature conforming to Table 401-2. Place WMA at temperatures conforming to Subsection 401.03. Measure temperature of the asphalt concrete mix in the hauling vehicle just before dumping into the spreader or measure it in the windrow immediately before pickup.

Place the asphalt concrete mix with a paver conforming to Subsection 401.05. Control horizontal alignment using a reference line. Automatically control the grade and slope from reference lines, a ski and slope control device, or dual skis. Use skis having a minimum length of 20 feet (6 meters).

In areas where mechanical spreading and finishing is impractical, place and finish the asphalt concrete mix with alternate equipment to produce a uniform surface closely matching the surface obtained when using a mechanical paver.

Offset the longitudinal joint of one layer at least 6 inches (150 millimeters) from the joint in the layer immediately below. Make the longitudinal joint in the top layer along the striped centerline of two-lane roadways or at the lane lines of roadways with more than two lanes.

401.14 Compacting. Furnish at least three rollers, with at least one being a pneumatic-tire roller. Furnish one roller each for breakdown, intermediate, and finish rolling. Size the rollers to achieve the required results. Operate rollers according to the recommendation of the manufacturer. Do not use diesel fuel as a release agent with rollers used to compact asphalt concrete mix.

Monitor the compaction process with nuclear density gauges calibrated to the control strip core density test results and compact according to Subsection 401.17(c).

Take nuclear gauge density readings and cut and test core samples according to Table 401-8.

Compact the asphalt concrete mix with alternate equipment to obtain the required compaction along forms, curbs, headers, walls, and other places inaccessible to rollers.

401.15 Joints, Trimming Edges, and Cleanup. Complete pavement construction of adjacent traffic lanes to the same elevation within 24 hours. If elevation differences exceeding 3 inches (75 millimeters) between adjacent lanes are left overnight, sign with "*Uneven Lanes*" warning signs and provide a 1V:3H fillet.

Make transverse joints vertical to the depth of the new pavement at connections to existing pavements and previously placed lifts. Form transverse joints by cutting back the previous run to expose the full-depth course.

Apply an asphalt tack coat to the edge of both transverse and longitudinal joints according to Section 412.

Place the asphalt concrete mix as continuously as possible. Do not pass rollers over an unprotected edge of freshly laid asphalt concrete mix.

Dispose of material trimmed from the edges and other discarded asphalt concrete mix according to Subsection 211.02(a)(2).

401.16 Pavement Roughness. Measure the profile of the pavement surface according to the designated pavement roughness type. In addition, construct pavement surfaces to meet the requirements of Subsection 401.16(e).

(a) Profile measurement. The CO will use profile measurements to determine the Mean Roughness Index (MRI) values for the traveled way using the current version of Profile Viewer and Analysis (ProVAL) software. The CO will also determine areas of localized roughness. The MRI and areas of localized roughness will be used to determine payment for the designated pavement roughness type and pavement areas requiring surface corrections.

Conform to the following:

(1) Equipment. Provide an ASTM E950, Class 1 inertial profiling system conforming to AASHTO M 328 and certified according to AASHTO R 56. Provide copies of the system certifications at least 21 days before profiling begins. Display a current decal on the equipment indicating the expiration date of the certifications.

The CO may perform verification testing, equipment validation, or both as follows:

(a) Verification testing. Verification testing will consist of the CO profiling a section of pavement and comparing the results against the Contractor's results for the same section of pavement. Comparison runs will be made within 21 days of each other. The Contractor's results will be considered verified if the CO's International Ride Index (IRI) for each wheel path differs from the Contractor's IRI for the same wheel path by no more than 10 percent of their mean. Do not use equipment that fails verification.

(b) Equipment validation. Equipment validation will consist of determining a cross correlation value on at least one section of pavement having a minimum length of 528 feet (161 meters). The Contractor's profiler and the CO's profiler will be cross correlated on the same day. Coordinate and schedule the equipment validation date at least 14 days before the validation date. The CO will determine the location of the cross correlation segments. The Contractor's equipment will be considered validated if the cross correlation value is greater than or equal to 0.90. Do not use equipment that fails validation.

(2) Personnel. Provide the following:

(a) A profile system operator certified according to AASHTO R 56. Submit copies of the operator's certifications at least 21 days before profiling begins.

(b) Flaggers, pilot car operations, or other temporary traffic control according to Section 635 as required.

(3) Measuring. The CO will identify the beginning and ending points of the profile measurements. Measure the pavement profile in both wheel paths using a sensor path spacing of 65 - 71 inches (1650 - 1800 millimeters) and centered in the traveled way of the lane. Operate the inertial profiler according to AASHTO R 57 and the manufacturer's recommendations. Do not apply filters when collecting profile data. Filtering will be applied during profile analysis in ProVAL. Collect profile data (elevation and distance) at a maximum interval of 2 inches (50 millimeters). Provide a lead-in distance of at least 150 feet (45 meters) after reaching the testing speed. Use the profiler's automatic start/stop activation when collecting data.

The CO will identify excluded areas. Cattle guards, bridges not being overlaid, and turning lanes, passing lanes, side roads, and ramps less than 1,000 feet (300 meters) in length will be excluded from profile measurement, the calculation of MRI, and the determination of localized roughness. Use event markers to mark the beginning and ending location of areas to be excluded from profile measurement. Measure excluded areas with a straightedge according to Subsection 401.16(e).

Coordinate profiling operations with the CO. Export each profile (elevation, distance data, header, and marker information) in pavement profile format (ppf) to a CD or DVD and submit after profiling. Do not submit non-continuous data files.

Use the following naming convention for electronic file submissions:

(a) For Type I and Type II pavement roughness:

[Project Name (or abbreviation)] _ [beginning station_to_ending station] _ [Initial or Final],

Beaver_Cr_Rd_25+50_to_387+35_Initial.ppf.

(b) For Type III pavement roughness:

[Project Name (or abbreviation)] _ [beginning station_to_ending station],

Beaver_Cr_Rd_25+50_to_387+35.ppf.

(4) Evaluation. The CO will review and analyze profile measurements. The MRI will be calculated from profile measurements using ProVAL.

Using ProVAL, a high pass filter length of 300 feet (90 meters) and a low pass filter of 10 inches (250 millimeters) will be applied to the profiles. Individual MRI values are determined by averaging the IRI value from each wheel path. Fixed interval MRI values are reported as an average of the individual MRI values over the fixed interval length. An overall MRI value will be determined by averaging the individual MRI values, excluding segments less than 25 feet (7.62 meters) for Type I and Type II pavement roughness or 528 feet (161 meters) for Type III pavement roughness.

Areas of localized roughness will be identified by using ProVAL's continuous MRI function with a segment length of 25 feet (7.62 meters). This will yield an average MRI value and a length for each area of localized roughness which exceeds the localized roughness threshold value of every possible 25-foot (7.62-meter) segment. Areas for which the continuous report exceeds the threshold MRI value for the specified roughness type will be considered a defective area requiring correction. When corrections are not allowed, a reduction in payment will be applied according to Subsection 401.16(f). No deduction will be made for areas of localized roughness identified within 12.5 feet (3.81 meters) of the beginning or end of a profile section or within 12.5 feet (3.81 meters) of excluded areas. Measure these areas with a straightedge according to Subsection 401.16(e).

Correct areas of localized roughness according to Subsection 401.16(g).

(b) Type I pavement roughness. Measure the profile of the initial pavement surface before construction activities disturb the existing pavement surface. The initial pavement surface is defined as the existing pavement surface before construction actives begin. The localized roughness threshold computed to the nearest whole number for Type I pavement roughness is equal to the following:

Localized Roughness Threshold = Initial Overall MRI + $1.881(S_{25})$

where:

Initial Overall MRI = MRI obtained before construction activities begin.

S_{25} = sample standard deviation of the 25 foot (7.62 meters) fixed interval MRI values.

Do not proceed with work that will disturb the initial pavement surface until the CO's analysis is complete.

Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving. The original overall surface MRI will be used in conjunction with the final overall MRI to determine an overall percent improvement for the entire traveled way.

The overall percent improvement in MRI will be determined to one decimal place for the traveled way according to the following formula:

% Improvement = [(Initial Overall MRI – Final Overall MRI) / Initial Overall MRI] × 100

Table 401-3 will be used to determine the final pay factor (PF_{rough}) for the traveled way to two decimal places. When the percent improvement is less than 25.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile (1.105 meters per kilometer), Type III-A from Table 401-5 will be used to determine the final PF_{rough}.

Correct areas of localized roughness according to Subsection 401.16(g). If a pavement has an overall negative percent improvement, place a minimum 1-inch (25-millimeter) overlay over the entire paved surface.

Table 401-3
Type I Pavement Roughness Pay Factors

Type I-A	**Type I-B**	
Percent Improvement (%)	**Percent Improvement (%)**	**Pay Factor (PF_{rough})**
Greater than 50.0	Greater than 45.0	PF = 1.05
47.6 – 50.0	44.0 – 45.0	PF = 1.04
45.1 – 47.5	43.0 – 43.9	PF = 1.03
43.6 – 45.0	41.6 – 42.9	PF = 1.02
42.1 – 43.5	40.1 – 41.5	PF = 1.01
25.0 – 42.0	20.0 – 40.0	PF = 1.00
24.0 – 24.9	19.0 – 19.9	PF = 0.99
23.0 – 23.9	18.0 – 18.9	PF = 0.98
22.0 – 22.9	17.0 – 17.9	PF = 0.97
21.0 – 21.9	16.0 – 16.9	PF = 0.96
20.0 – 20.9	15.0 – 15.9	PF = 0.95
19.0 – 19.9	14.0 – 14.9	PF = 0.94
18.0 – 18.9	13.0 – 13.9	PF = 0.93
17.0 – 17.9	12.0 – 12.9	PF = 0.92
16.0 – 16.9	11.0 – 11.9	PF = 0.91
15.0 – 15.9	10.0 – 10.9	PF = 0.90
14.0 – 14.9	9.0 – 9.9	PF = 0.89
13.0 – 13.9	8.0 – 8.9	PF = 0.88
12.0 – 12.9	7.0 – 7.9	PF = 0.87
11.0 – 11.9	6.0 – 6.9	PF = 0.86
10.0 – 10.9	5.0 – 5.9	PF = 0.85
5.0 – 9.9	4.0 – 4.9	PF = 0.80
0.0 – 4.9	0.0 – 3.9	PF = 0.70
Negative % Improvement	Negative % Improvement	Correct & overlay

(c) Type II pavement roughness. Measure the profile of the initial pavement surface before construction activities disturb the pavement surface. The initial pavement surface is defined as the original existing pavement surface before construction actives begin. The localized roughness threshold computed to the nearest whole number for Type II pavement roughness is equal to the following:

Localized Roughness Threshold = Initial Overall MRI + 1.282(S_{25})

where:

Initial Overall MRI = MRI obtained before construction activities begin.

(S_{25}) = sample standard deviation of the 25-foot (7.62-meter) fixed interval MRI values.

Do not proceed with work that will disturb the initial pavement surface until the CO's analysis is complete.

Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving. The original overall surface MRI will be used in conjunction with the final overall MRI to determine an overall percent improvement for the entire traveled way.

The overall percent improvement in MRI will be determined to one decimal place for the traveled way according to the following formula:

% Improvement = [(Initial Overall MRI – Final Overall MRI) / Initial Overall MRI] × 100

Table 401-4 will be used to determine the final PF_{rough} for the traveled way to two decimal places. When the percent improvement is less than 49.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile (1.105 meters per kilometer), Type III-A from Table 401-5 will be used to determine the final PF_{rough}.

Correct areas of localized roughness according to Subsection 401.16(g). If a pavement has less than a 10.0 percent improvement, place a minimum 1-inch (25-millimeter) overlay over the entire paved surface.

Table 401-4
Type II Pavement Roughness Pay Factors

Type II-A	Type II-B	
Percent Improvement (%)	**Percent Improvement (%)**	**Pay Factor (PF_{rough})**
Greater than 60.0	Greater than 50.0	PF = 1.05
58.6 – 60.0	49.0 – 50.0	PF = 1.04
57.6 – 58.5	48.0 – 48.9	PF = 1.03
56.6 – 57.5	47.0 – 47.9	PF = 1.02
55.1 – 56.5	45.0 – 46.9	PF = 1.01
49.0 – 55.0	35.0 – 44.9	PF = 1.00
48.0 – 48.9	34.0 – 34.9	PF = 0.99
47.0 – 47.9	33.0 – 33.9	PF = 0.98
46.0 – 46.9	32.0 – 32.9	PF = 0.97
45.0 – 45.9	31.0 – 31.9	PF = 0.96
44.0 – 44.9	30.0 – 30.9	PF = 0.95
43.0 – 43.9	29.0 – 29.9	PF = 0.94
42.0 – 42.9	28.0 – 28.9	PF = 0.93
41.0 – 41.9	27.0 – 27.9	PF = 0.92
40.0 – 40.9	26.0 – 26.9	PF = 0.91
38.0 – 39.9	25.0 – 25.9	PF = 0.90
36.0 – 37.9	24.0 – 24.9	PF = 0.89
35.0 – 35.9	23.0 – 23.9	PF = 0.88
34.0 – 34.9	22.0 – 22.9	PF = 0.87
33.0 – 33.9	21.0 – 21.9	PF = 0.86
31.0 – 32.9	20.0 – 20.9	PF = 0.85
25.0 – 30.9	16.0 – 19.9	PF = 0.80
10.0 – 24.9	7.5 – 15.9	PF = 0.70
Less than 10.0	Less than 7.5	Correct & overlay

(d) Type III pavement roughness. Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving. Pay factors from Table 401-5 will be used in conjunction with the long continuous histogram printout from ProVAL's Smoothness Assurance Analysis function and by utilizing a long continuous 528-foot (161-meter) segment length for analysis. The final PF_{rough} is equal to the sum of the products of the individual pay factors indicated in Table 401-5 multiplied by the ratio of individual lane miles (lane kilometers)to the overall project lane miles (lane kilometers)and by ProVAL's corresponding histogram percentages, divided by 100. The final PF_{rough} will be determined to three decimal places.

If the final overall MRI for the entire traveled way is greater than the values shown in Table 401-5, correct the traveled way according to Subsection 401.16(g).

Table 401-5
Type III Pavement Roughness Pay Factors

Mean Roughness Index (MRI) Type III-A in/mi (m/km)	**Mean Roughness Index (MRI) Type III-B in/mi (m/km)**	**Pay Factor (PF_{rough})**
Localized roughness threshold 140 in/mi (2.210 m/km)	Localized roughness threshold 140 in/mi (2.210 m/km)	
If MRI of entire roadway is greater than 125 in/mi (1.973 m/km)	If MRI of entire roadway is greater than 135 in/mi (2.131 m/km)	REJECT
Greater than 95.0 (1.50)	Greater than 110.0 (1.74)	0.700
95.0 – 90.0 (1.50 – 1.42)	110.0 – 105.0 (1.74 – 1.66)	0.800
90.0 – 85.0 (1.42 – 1.34)	105.0 – 100.0 (1.66 – 1.58)	0.850
85.0 – 80.0 (1.34 – 1.26)	100.0 – 95.0 (1.58 – 1.50)	0.900
80.0 – 75.0 (1.26 – 1.18)	95.0 – 90.0 (1.50 – 1.42)	0.960
75.0 – 70.0 (1.18 – 1.10)	90.0 – 85.0 (1.42 – 1.34)	0.980
70.0 – 65.0 (1.10 – 1.02)	85.0 – 80.0 (1.34 – 1.26)	1.000
65.0 – 60.0 (1.02 – 0.94)	80.0 – 75.0 (1.26 – 1.18)	1.010
60.0 – 55.0 (0.94 – 0.86)	75.0 – 70.0 (1.18 – 1.10)	1.020
55.0 – 50.0 (0.86 – 0.78)	70.0 – 65.0 (1.10 – 1.02)	1.025
50.0 – 45.0 (0.78 – 0.70)	65.0 – 60.0 (1.02 – 0.94)	1.030
45.0 – 40.0 (0.70 – 0.62)	60.0 – 55.0 (0.94 – 0.86)	1.035
40.0 – 35.0 (0.62 – 0.54)	55.0 – 50.0 (0.86 – 0.78)	1.040
35.0 – 30.0 (0.54 – 0.46)	50.0 – 45.0 (0.78 – 0.70)	1.045
Less than 30.0 (0.46)	Less than 45.0 (0.70)	1.050

(e) Type IV straightedge measurement. Use a 10 foot (3.0 meters) metal straightedge to measure at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge in excess of ¼ inches (6 millimeters) measured between two contacts of the straightedge or deviations in excess of ¼ inches (6 millimeters) measured at the end of the straightedge. Correct defective areas according to Subsection 401.16(g).

(f) Localized roughness and straightedge measurement pay reduction. Each area of localized roughness exceeding the threshold MRI specified for the designated pavement roughness type will receive a reduction in payment according to Table 401-6.

Each defective area as determined by a 10-foot (3.0-meter) metal straightedge will receive a reduction in payment according to Table 401-6.

Table 401-6
Localized Roughness and Straightedge Measurement Pay Reductions

Type I	Type II & IV		Type III	
Deduction per Occurrence	**Deduction per Occurrence**	**Localized Roughness Limit MRI**	**Localized Roughness Limit MRI, in/mi (m/km)**	**Deduction per Occurrence**
$200	$300	Computed MRI value per Subsection 401.16(b) for Type I 401.16(c) for Type II 401.16(d) for Type III	140.0 – 169.9 (2.208 – 2.680)	$300
			170.0 – 179.9 (2.681 – 2.838)	$450
			180.0 – 189.9 (2.839 – 2.995)	$600
			190.0 – 199.9 (2.996 – 3.154)	$750
			200.0 – 209.9 (3.155 – 3.311)	$900
			210.0 – 219.9 (3.312 – 3.469)	$1,200
			220.0 – 229.9 (3.470 – 3.626)	$1,500
			230.0 – 239.9 (3.627 – 3.784)	$2,000
			≥ 240.0 (3.785)	$4,000

(g) Defective area correction. Obtain approval before starting corrective work. Allow 7 days for review and approval of correction method proposal.

Correct defective areas by one of the following methods:

(1) Milling. Replace the defective area by milling at least one-half the pavement depth and repaving with the approved asphalt concrete mix. Mill the defective area according to Section 413.

(2) Saw cutting. Replace the defective area by saw cutting and removing the defective area and repaving with the approved asphalt concrete mix. Saw cut and remove the defective area according to Section 203.

(3) Grinding. Use a diamond blade machine to grind off the defective surface area. Provide the manufacturer and model of the equipment to be used. Identify the beginning and ending station of each grind location, the grinding depth, and lateral extent of grinding. Optimize the endpoints of the areas where a grinder is to be applied using ProVAL's Smoothness Assurance function in conjunction with the grinding simulation function. Submit the type of seal to be placed after grinding is completed for approval. Place seals according to Section 409 or 410. Limit the grinding depth to 12.5 percent of the design pavement thickness. If grinding in excess of this depth, provide a minimum 1-inch (25-millimeter) overlay.

(4) Other. Submit a proposal for approval for other correction methods not listed above.

After corrections are made, re-measure the pavement profile according to Subsection 401.16(a). Data from the re-measurement will be analyzed to determine the MRI or percent improvement, areas of localized roughness, and the final PF_{rough}. If correction and re-measurement of the surface is required, the maximum allowable pay factor under Subsection 401.19 is 1.00.

If corrections are not allowed, no adjustment will be made to the final PF_{rough} or localized roughness pay deductions.

401.17 Acceptance. See Table 401-8 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler, antistrip additives, and WMA additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt content, VMA, and core density will be evaluated under Subsection 106.05. Pavement roughness will be evaluated under Subsection 106.04. Asphalt binder will be evaluated under Subsections 106.03 and 106.04. Evaluations will consider the following:

(a) Asphalt content. The upper and lower specification limits are the approved JMF target value plus or minus 0.4 percent;

(b) VMA. The lower specification limit is the value shown in Table 401-1. After the JMF has been verified according to Subsections 401.03 and 401.12, use the Contractor's combined coarse and fine bulk specific gravity of aggregate G_{sb} values to calculate VMA on field produced asphalt concrete mix samples;

(c) Density (core). The lower specification limit is 91.0 percent of the maximum specific gravity (density) determined according to AASHTO T 166 and AASHTO T 209.

The percent compaction will be determined using the average maximum specific gravity (AASHTO T 209) from all samples tested each day;

(d) Pavement roughness. The evaluation for payment will be made after defective areas are addressed. See Subsection 401.16(g); and

(e) Asphalt binder. The pay factor is determined from Table 401-7.

Construction of the HMA or WMA pavement course will be evaluated under Subsections 106.02 and 106.04.

Measurement

401.18 Measure the Section 401 pay items listed in the bid schedule according to Subsection 109.02.

Payment

401.19 The accepted quantities will be paid at the contract price per unit of measurement for the Section 401 pay items listed in the bid schedule, except the asphalt concrete pavement contract price will be adjusted according to Subsections 106.05, 401.16, and Table 401-7. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for asphalt concrete pavement will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is calculated as follows:

$PF_{material} = 1 + [(PF_{Volumetric} – 1) + (PF_{PG} – 1)]$

where:

$PF_{material}$ = Material pay factor.

$PF_{Volumetric}$ = Pay factor for asphalt concrete pavement. $PF_{Volumetric}$ is the lowest single pay factor determined for asphalt binder content, VMA, and core density.

PF_{PG} = Pay factor for asphalt binder. The PF_{PG} formula is as follows:

$PF_{PG} = (PF_1 + PF_2 + PF_3 + ….PF_n) / n$

where:

$PF_{\#}$= For each sample, the lowest pay factor determined from any test in Table 401-7. If the lowest pay factor for a sample is in reject, the sample's pay factor is zero.

n = Number of samples tested.

If either the pay factor for the asphalt binder (PF_{PG}) or the pay factor for asphalt concrete pavement ($PF_{Volumetric}$) is below 0.75, the lot for asphalt concrete pavement is in reject.

When the contract specifies a pavement roughness Type I, Type II, or Type III, a separate pay adjustment will be made for pavement roughness calculated as follows:

Type I, Type II, or Type III Pay Adjustment = $(RF)(PF_{rough} - 1.00)(L) – (LRPR)$

where:

PF_{rough} = Pay factor from Tables 401-3, 401-4, or 401-5.

L = Total project length in lane miles (lane kilometers).

LRPR = Localized roughness pay reduction from Table 401-6.

RF = Roughness factor: 40,000 U.S. Customary (24,800 Metric).

Table 401-7
Asphalt Binder Pay Factor Table

Tests on Original	Specifications [1]	Pay Factor =					
		1.01	**1.00**	**0.95**	**0.90**	**0.75**	**Reject**
Dynamic shear rheometer, kPa	≥ 1.00	≥ 1.17	1.16 – 1.00	0.99 – 0.89	0.88 – 0.77	0.76 – 0.50	< 0.50
Tests after Rolling Thin Film Oven (RTFO)							
Dynamic shear rheometer, kPa	≥ 2.20	≥ 2.69	2.68 – 2.20	2.19 – 1.96	1.95 – 1.43	1.42 – 1.10	< 1.10
Tests on Pressure Aging Vessel (PAV)							
Dynamic shear rheometer, kPa	≤ 5,000	4,711 ≤	4,712 – 5,000	5,001 – 5,289	5,290 – 5,578	5,579 – 5,867	> 5,867
Bending beam rheometer, s, MPa	≤ 300	≤ 247	248 – 300	301 – 338	339 – 388	389 – 449	≥ 450
Bending beam rheometer, m-value	≥ 0.300	≥ 0.320	0.319 – 0.300	0.299 –0.294	0.293 –0.278	0.277 – 0.261	< 0.261

(1) See Subsection 702.01.

Table 401-8
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Asphalt concrete aggregate (703.07)	Measured and tested for conformance (106.04 & 105)	Aggregate quality	–	Subsection 703.07	1 per type and source of material	Source of material	Yes	Before production	Not required when using Government-provided source
Asphalt binder (702.01)	"	Quality	–	AASHTO M 320	"	Asphalt supplier or mixing plant	"	"	–
Asphalt concrete aggregate (703.07)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required when using a pre-crushed commercial source

Table 401-8 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Asphalt concrete mixture	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	30 days before producing	–
		RAP asphalt binder content	–	AASHTO T 308	"	"	"	"	–
		Bulk specific gravity of aggregate (coarse and fine)	–	AASHTO T 84 & T 85	"	"	"	"	–
		VMA	–	AASHTO R 35	"	–	"	"	–
		VFA	–	"	"	–	"	"	–
		Air voids	–	"	"	–	"	"	–
		Tensile strength ratio	–	AASHTO T 283	"	–	"	"	–

Table 401-8 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt concrete pavement	Statistical (106.05)	Gradation		AASHTO T 30	3 minimum	Behind the paver before compaction	Yes	6 hours	–
		No. 4 (4.75 mm)	I						
		No. 30 (600 µm)	I						
		No. 200 (75 µm)	I						
		Other specified sieves	II						
		Asphalt content[(1)]	I	AASHTO T 308	"	"	"	"	–
		VMA	I	AASHTO R 35	"	"	"	"	–
		Density[(2)]	I	AASHTO T 166	5 minimum	In-place after compaction	"	24 hours	Deliver cores to CO after determining specific gravity and compaction

Table 401-8 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Asphalt concrete pavement	Measured and tested for conformance (106.04)	Mix temperature	–	–	First load and as determined by CO thereafter	Hauling vehicle before dumping or windrow before pickup	No	Immediately upon completion of test	–
		Maximum specific gravity[4]	–	AASHTO T 209	3 minimum	Behind the paver before compaction	Yes	24 hours	–
	Process control (153.03)	Density	–	ASTM D2950	5 minimum	At core location before coring	No	24 hours	See Subsection 401.12
Production									
Asphalt concrete pavement	Statistical (106.05)	Asphalt content[1]	I	AASHTO T 308	1 per 700 tons (650 metric tons)	Behind the paver before compaction	Yes	6 hours	–
		VMA	I	AASHTO R 35	"	"	"	"	–
		Density[2]	I	AASHTO T 166	"	In-place after compacting	"	24 hours	Deliver cores to CO after testing is completed

Table 401-8 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt concrete pavement	Measured and tested for conformance (106.04)	Placement temperature	–	–	First load and as determined by CO thereafter	Hauling vehicle before dumping, or windrow before pickup	No	Immediately upon completion of measurement	–
		Maximum specific gravity[3][4]	–	AASHTO T 209	Minimum 1 per day	Behind the paver before compaction	Yes	24 hours	–
Asphalt binder (702.01)	Measured and tested for conformance (106.04)	Quality	See Table 401-7	AASHTO M 320	1 per 2000 tons (1800 metric tons) of mix	In line between tank and mixing plant	Yes, 2 1-quart (1-liter) samples	–	Test by Government

Table 401-8 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt concrete pavement	Process control (153.03)	Gradation at plant	–	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	No	24 hours	–
		Gradation at paver	–	AASHTO T 30	1 per 700 tons (650 metric tons) of mix	Behind the paver before compaction	"	"	–
		Moisture content of aggregates	–	AASHTO T 255	Contractor determined	Stockpile	"	"	–
		Density	–	ASTM D2950	1 per 500 feet (150 meters)	In-place after compacting	"	"	–
		Air voids	–	AASHTO T 312 & T 166	1 per 700 tons (650 metric tons) of mix	Behind the paver before compaction	No	24 hours	–
		VFA	–	AASHTO R 35	"	"	"	"	–

Table 401-8 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Asphalt concrete pavement	Measured and tested for conformance (106.04)	Type I roughness, before construction (Initial MRI)	–	AASHTO R 56 & R 57	See Subsection 401.16	Left and right wheel paths	No	Within 14 days of Notice to Proceed	Original surface before construction
		Type I roughness, after construction (Final MRI)	–	"	"	"	"	Within 21 days after completing paving	–
		Type II roughness, before construction (Initial MRI)	–	"	"	"	"	Within 14 days of Notice to Proceed	Original surface before construction
		Type II roughness, after construction (Final MRI)	–	"	"	"	"	Within 21 days after completing paving	–
		Type III roughness (Final MRI)	–	"	"	"	"	"	–
	Process control (153.03)	Surface tolerance	–	Straightedge measurements Subsection 401.16(e)	Contractor determined	See Subsection 401.16(e)	"	24 hours	–

Table 401-8 (continued)
Sampling, Testing, and Acceptance Requirements

(1) Use AASHTO T 308, Method A. Calculate the asphalt binder content by weighing the sample before and after the burn using a calibrated external balance.

(2) Cut two 6-inch (150-millimeter) diameter side by side cores. Remove them with a core retriever and fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling and temperature. Submit one core for verification testing. Dry the other core to constant mass at 125±5 °F (52±3 °C) or vacuum dry it according to ASTM D7227 before performing the core density and measuring the thickness. Use 62.245 pounds per cubic foot (997.1 kilograms per cubic meter) to convert specific gravity to density.

(3) After production paving has begun, use the average maximum specific gravity value (AASHTO T 209) for each day to adjust the percent compaction for the cores that represent that day's paving.

(4) Do not use the supplemental procedure for mixtures containing porous aggregate (dry back method of AASHTO T 209).

Section 402. — ASPHALT CONCRETE PAVEMENT BY HVEEM OR MARSHALL MIX DESIGN METHOD

Description

402.01 This work consists of constructing one or more courses of asphalt concrete pavement using hot or warm mix asphalt (HMA or WMA).

HMA and WMA asphalt concrete pavement class is designated according to Table 402-1.

Pavement roughness type is designated according to Subsection 402.16. If no roughness type is designated use Type IV.

Asphalt binder is designated according to AASHTO M 320.

Antistrip additive type is designated according to Subsection 702.05. When no type is designated use Type 3 (lime).

Material

402.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Asphalt concrete aggregate	703.07
Mineral filler	725.05

Construction Requirements

402.03 Composition of Mix (JMF). Provide asphalt concrete mixes of aggregate, asphalt binder, recycled asphalt pavement (RAP), and additives that meet the applicable aggregate gradation in Table 703-4 and design parameters (a), (c), and (d) or (b), (c), and (d) in Table 402-1 for the class of mix listed in the bid schedule.

Apply asphalt concrete mix design requirements for HMA to the development of the WMA mix design. Provide modifications to the process required for WMA technology. Submit modifications to the asphalt concrete mix design process according to Appendix X.2 of AASHTO R 35, *Special Mix Design Considerations and Practices for Warm Mix Asphalt (WMA)* for approval by the CO.

Table 402-1
Asphalt Concrete Mix Requirements

Design Parameters	Class of Mix		
	A	**B**	**C**
(a) Hveem (AASHTO T 246 and AASHTO T 247)			
Percent air voids[(1)]	3.0 – 5.0	3.0 – 5.0	3.0 – 5.0
Stabilometer, minimum	37	35	30
Voids in mineral aggregate, minimum, %	See Table 402-2		
(b) Marshall (AASHTO T 245)			
Percent air voids [(1)]	3.0 – 5.0	3.0 – 5.0	3.0 – 5.0
Compaction, number of blows each end of test specimen	75	50	50
Stability, pounds (kN) min.	2,000 (8.89)	1,500 (6.67)	1,000 (4.44)
Flow, 0.01 inches (0.25 mm)	8 – 14 (8 – 14)	8 – 16 (8 – 16)	8 – 20 (8 – 20)
Voids in mineral aggregate, minimum, %	See Table 402-2		
(c) Moisture Susceptibility (AASHTO T 283) [(2)]			
Tensile strength ratio, min.	0.80	0.80	0.80
(d) Dust to binder ratio[(3)]	0.8 – 1.6	0.8 – 1.6	0.8 – 1.6

(1) The percent of air voids is based on AASHTO T 166, AASHTO T 209, and AASHTO T 269. Maximum specific gravity (density) is based on AASHTO T 209.

(2) Use 4-inch (100-millimeter) diameter specimens. AASHTO T 283 requires a freeze-thaw cycle.

(3) Dust to binder ratio is the percent of material including lime, bag-house fines, and other mineral matter added to the mixture. Calculate the ratio using the effective asphalt content calculated by mass of mix.

Table 402-2
Voids in Mineral Aggregate (VMA)
Hveem or Marshall Mix Design

Sieve Size [1]	Voids in Mineral Aggregate, Minimum, % [2][3]	
	Hveem	**Marshall**
No. 4 (4.75 mm)	16.0	18.0
⅜ inch (9.5 mm)	14.0	16.0
½ inch (12.5 mm)	13.0	15.0
¾ inch (19 mm)	12.0	14.0
1 inch (25 mm)	11.0	13.0

(1) The largest sieve size listed in the applicable specification upon which material is permitted to be retained.

(2) VMA to be determined according to AASHTO R 35.

(3) When mineral filler or hydrated lime is used, include in the calculation for compliance with the VMA.

(a) RAP. See Subsection 401.03(a).

(b) Baghouse fines. See Subsection 401.03(b).

(c) Submission. Submit written JMFs and associated material with FHWA Form 1607, *Worksheet For A Hveem Mix Design AASHTO T 246* or FHWA Form 1622, *Worksheet For A Marshall Mix Design AASHTO T 245* for verification at least 30 days before the control strip. Include a signed statement prepared by the testing laboratory that certifies the proposed JMF meets the requirements and can be compacted in the field during production. For each proposed JMF, submit the following:

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each sieve size for the aggregate blend; and

(2) Designate target values within the gradation band specified for the nominal maximum size aggregate grading shown in Table 703-5.

(b) Source and percentage of each stockpile to be used.

(c) Average gradation of each stockpile.

(d) Representative samples from each stockpile. Use split samples of material taken at the same time samples are taken for testing by the Contractor's laboratory.

(1) 600 pounds (270 kilograms) of aggregates proportioned by each stockpile according to the JMF; and

(2) 10 pounds (4.5 kilograms) of mineral filler if proposed for the JMF.

(e) Results of aggregate quality tests performed within 1 year of use. For aggregate quality tests, see Subsection 703.07.

(2) Asphalt binder. See Subsection 401.03(c)(2).

(3) Antistrip additives. See Subsection 401.03(c)(3).

(4) RAP. See Subsection 401.03(c)(4).

(5) WMA technology and additive information. See Subsection 401.03(c)(5).

(d) Verification. The verification process starts when required documentation and material have been received. When the JMF is verified, begin asphalt concrete mix production for the control strip.

(1) Aggregate gradations. See Subsection 401.03(d)(1).

(2) RAP asphalt binder content and gradation. See Subsection 401.03(d)(2).

(3) Bulk specific gravity of aggregate (G_{sb}). See Subsection 401.03(d)(3).

(4) Hveem stabilometer value. The Contractor's Hveem stabilometer value is verified if the CO's result is above the minimum specification limit in Table 402-1.

(5) Marshall stability and flow value. The Contractor's Marshall stability and flow values are verified if the CO's results meet the requirements in Table 402-1.

(6) Air voids (V_a). See Subsection 401.03(d)(6).

(7) Tensile strength ratio (TSR). See Subsection 401.03(d)(7).

(e) Changes and resubmissions. See Subsection 401.03(e).

402.04 Mixing Plant. See Subsection 401.04.

402.05 Equipment. See Subsection 401.05.

402.06 Surface Preparation. See Subsection 401.06.

402.07 Weather Limitations. See Subsection 401.07.

402.08 Asphalt Preparation. See Subsection 401.08.

402.09 Aggregate Preparation. See Subsection 401.09.

402.10 Mixing. See Subsection 401.10.

402.11 Hauling. See Subsection 401.11.

402.12 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-paving preparatory phase meeting at least 3 days before the start of paving operations according to Subsection 153.04(a). In addition, be prepared to discuss the following:

(1) Calibration certification for the Hveem or Marshall compactor; and

(2) Asphalt and aggregate correction factors according to AASHTO T 308 and AASHTO T 30 on FHWA Form 1640, *Worksheet for Ignition Furnace Binder Correction Factor AASHTO T 308*. If RAP is included as part of the JMF, provide the asphalt and aggregate correction factors according to AASHTO T 30 and the FLH Addendum to AASHTO T 308 on FHWA Form 1648, *Worksheet For Ignition Furnace Binder Correction Factor And Aggregate Gradation Correction Factor For Mixes Including Rap*.

(b) Control strip. Provide 7 days notice before beginning production of an asphalt concrete mix.

On the first day of production, produce sufficient asphalt concrete mix to construct a 1000-foot (300-meter) long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using asphalt concrete mix production, lay-down, and compaction procedures intended for the entire mix. Cease production after construction of the control strip until the asphalt concrete mix and the control strip are evaluated for acceptance.

(1) Mixture. Take and test at least three control strip asphalt concrete mix samples and evaluate according to Subsection 402.17. The asphalt concrete mix is acceptable if all test results are within specification limits for gradation and asphalt content and the calculated pay factor for gradation and asphalt content is 0.90 or greater.

(2) Compaction. Take nuclear density gauge readings behind each roller pass to determine the roller pattern necessary to achieve required density.

Take nuclear gauge density readings and cut core samples at least five locations within the control strip. Test cores according to Subsection 401.17. Density is acceptable if all tests are above the specification limit or the calculated pay factor is 0.90 or greater. Furnish the CO with documented nuclear gauge readings and correlations of the readings to the core specific gravities at completion of control strip.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in unacceptable control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed pavement. Tests used for the control strip will not be included in the evaluation for payment according to Subsection 106.05. When a control strip is verified and accepted, full production may begin.

Use these start-up procedures when producing material from a different plant or when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.05.

402.13 Placing and Finishing. See Subsection 401.13.

402.14 Compacting. See Subsection 401.14.

402.15 Joints, Trimming Edges, and Cleanup. See Subsection 401.15.

402.16 Pavement Roughness. See Subsection 401.16.

402.17 Acceptance. See Table 402-3 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler, antistrip additives, and WMA additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt content, core density and aggregate gradation will be evaluated under Subsection 106.05. Pavement roughness will be evaluated under Subsection 106.04. Asphalt binder will be evaluated under Subsections 106.03 and 106.04. Evaluations will consider the following:

(a) Asphalt content. The upper and lower specification limits are the approved JMF target value plus or minus 0.4 percent;

(b) Density (core). The lower specification limit is 91.0 percent of the maximum specific gravity (density) determined according to AASHTO T 166 and AASHTO T 209. The percent compaction will be determined using the maximum specific gravity (AASHTO T 209) from at least one production sample per day;

(c) Aggregate gradation. The upper and lower specification limits are the approved JMF target values plus or minus the allowable deviations shown in Table 703-5;

(d) Pavement roughness. The evaluation for payment will be made after defective areas are addressed. See Subsection 401.16(g); and

(e) Asphalt binder. The pay factor is determined from Table 401-7.

Construction of the HMA or WMA pavement course will be evaluated under Subsections 106.02 and 106.04.

Measurement

402.18 Measure the Section 402 pay items listed in the bid schedule according to Subsection 109.02.

Payment

402.19 The accepted quantities will be paid at the contract price per unit of measurement for the Section 402 pay items listed in the bid schedule, except for the asphalt concrete pavement, contract price will be adjusted according to Subsections 106.05, 402.16, and Table 401-7. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for asphalt concrete pavement will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is calculated as follows:

$$PF_{material} = 1 + [(PF_{Volumetric} - 1) + (PF_{PG} - 1)]$$

where:

$PF_{material}$ = Material pay factor.

$PF_{Volumetric}$ = Pay factor for asphalt concrete pavement. $PF_{Volumetric}$ is the lowest single pay factor determined for asphalt content, density, or aggregate gradation.

PF_{PG} = Pay factor for asphalt binder. The PF_{PG} formula is as follows:

$$PF_{PG} = (PF_1 + PF_2 + PF_3 + \ldots PF_n) / n$$

where:

$PF_{\#}$ = For each sample, the lowest pay factor determined from any test in Table 401-7. If the lowest pay factor for a sample is in reject, the sample's pay factor is zero.

n = Number of samples tested.

If either the pay factor for the asphalt binder (PF_{PG}) or the pay factor for asphalt concrete pavement ($PF_{Volumetric}$) is below 0.75, the lot for asphalt concrete pavement is in reject.

When the contract specifies a pavement roughness Type I, Type II or Type III, a separate pay adjustment will be made for pavement roughness calculated as follows:

Type I, Type II or Type III Pay Adjustment = $(RF)(PF_{rough} - 1.00)(L) – (LRPR)$

where:

PF_{rough} = Pay factor from Tables 401-3, 401-4, or 401-5.

L = Total project length in lane miles (lane kilometers) of traveled way as specified in the contract.

LRPR = Localized roughness pay reduction from Table 401-6.

RF = Roughness factor: 40,000 U.S. Customary (24,800 Metric).

Table 402-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Method Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Asphalt concrete aggregate (703.07)	Measured and tested for conformance (106.04 & 105)	Aggregate quality	–	Subsection 703.07	1 per type & source of material	Source of material	Yes	Before producing	Not required when using Government-provided source
Asphalt binder (702.01)	Measured and tested for conformance (106.04)	Quality	–	AASHTO M 320	"	Asphalt supplier or mixing plant	"	"	–
Asphalt concrete aggregate (703.07)	Process control (153.03)	Gradation	–	AASHTO T 27& T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required when using a pre-crushed commercial source

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Asphalt concrete mixture	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	30 days before paving	–
		RAP asphalt binder content	–	AASHTO T 308	"	"	"	"	–
		RAP asphalt gradation	–	AASHTO T 30	"	"	"	"	Dry gradation, no binder removed
		Bulk specific gravity of aggregate (coarse & fine)	–	AASHTO T 84 & T 85	"	"	"	"	–
		VMA	–	AASHTO R 35	"	–	"	"	–
		VFA	–	"	"	–	"	"	–
		Air voids	–	AASHTO T 269	"	–	"	"	–
		Hveem S-value	–	AASHTO T 246 & T 247	"	–	"	"	Required only for Hveem mix
		Marshall stability & flow	–	AASHTO T 245	"	–	"	"	Required only for Marshall mix
		Tensile strength ratio	–	AASHTO T 283	"	–	"	"	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt concrete pavement	Statistical (106.05)	Gradation:		AASHTO T 30	3 minimum	Behind the paver before compaction	Yes	6 hours	–
		½ in (12.5 mm)	I						
		No. 4 (4.75 mm)	I						
		No. 30 (600 µm)	I						
		No. 200 (75µm)	I						
		Other specified sieves	II						
		Asphalt content [(1)]	I	AASHTO T 308	"	"	"	"	–
		Density [(2)]	I	AASHTO T 166	5 minimum	In-place after compacting	"	24 hours	Deliver cores to CO after determining specific gravity and compaction

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt concrete pavement	Measured and tested for conformance (106.04)	Maximum specific gravity[4]	–	AASHTO T 209	3 minimum	Behind the paver before compaction	Yes	24 hours	–
		Mix temperature	–	–	First load & as determined by the CO thereafter	Hauling vehicle before dumping or windrow before pickup	No	Upon completion of test	–
	Process control (153.03)	Density	–	ASTM D2950	5 minimum	At core location before coring	No	24 hours	See Subsection 402.12

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Asphalt concrete pavement	Statistical (106.05)	Gradation		AASHTO T 30	1 per 700 tons (650 metric tons)	Behind the paver before compaction	Yes	6 hours	–
		½ in (12.5 mm)	I						
		No. 4 (4.75 mm)	I						
		No. 30 (600 µm)	I						
		No. 200 (75µm)	I						
		Other specified sieves	II						
		Asphalt content [(1)]	I	AASHTO T 308	"	"	"	"	–
		Density [(2)]	I	AASHTO T 166	"	In-place after compacting	"	24 hours	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt concrete pavement	Measured and tested for conformance (106.04)	Maximum specific gravity [3][4]	–	AASHTO T 209	Minimum 1 per day	Behind the paver before compaction	Yes	24 hours	–
		Placement temperature	–	–	First load and as determined by CO thereafter	Hauling vehicle before dumping, or windrow before pickup	No	Upon completion of measurement	–
Asphalt binder (702.01)	Measured and tested for conformance (106.04)	Quality	See Table 401-7	AASHTO M 320	1 per 2000 tons (1800 metric tons) of mix	In line between tank & mixing plan	Yes, 2 1-quart (1-liter) samples	–	Tested by Government
Asphalt concrete pavement	Process control (153.03)	Gradation at plant	–	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	No	24 hours	–
		Moisture content of aggregates	–	AASHTO T 255	Contractor determined	Stockpile	"	"	–
		Density	–	ASTM D2950	1 per 500 feet (150 meters)	In-place after compacting	"	"	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Asphalt concrete pavement	Measured and tested for conformance (106.04)	Type I pavement roughness, before construction (Initial MRI)	–	AASHTO R 56 & R 57	See Subsection 402.16	Left and right wheel paths	No	Within 14 days of Notice to Proceed	Original surface before construction
		Type I pavement roughness, after construction (Final MRI)	–	"	"	"	”	Within 21 days after completing paving	–
		Type II pavement roughness, before construction (Initial MRI)	–	"	"	"	”	Within 14 days of Notice to Proceed	Original surface before construction
		Type II pavement roughness, after construction (Final MRI)	–	"	"	"	”	Within 21 days after completing paving	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product (continued)									
Asphalt concrete pavement	Measured and tested for conformance (106.04)	Type III pavement roughness (Final MRI)	–	AASHTO R 56 & R 57	See Subsection 402.16	Left and right wheel paths	No	Within 21 days after completing paving	–
"	Process control (153.03)	Surface tolerance	–	Straightedge measurements Subsection 401.16(e)	Contractor determined	See Subsection 401.16(e)	"	24 hours	–

(1) Use AASHTO T 308, Method A. Calculate the asphalt binder content by weighing the sample before and after the burn using a calibrated external balance.

(2) Cut two 6-inch (150-millimeter) diameter side by side cores. Remove them with a core retriever and fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling and temperature. Submit one core for verification testing. Dry the other core to constant mass at 125±5 °F (52±3 °C) or vacuum dry it according to ASTM D7227 before performing the core density and measuring the thickness. Use 62.245 pounds per cubic foot (997.1 kilograms per cubic meter) to convert specific gravity to density.

(3) After production paving has begun, use the average maximum specific gravity value (AASHTO T 209) for each day to adjust the percent compaction for the cores that represent that day's paving.

(4) Do not use the supplemental procedure for mixtures containing porous aggregate (dry back method of AASHTO T 209).

Section 403. — ASPHALT CONCRETE

Description

403.01 This work consists of constructing asphalt concrete pavement using a hot or warm mix asphalt (HMA or WMA).

Asphalt concrete type is designated as Type I or Type II according to Subsection 403.02.

Construction Requirements

403.02 Composition of Mix (JMF). Conform to current state department of transportation material specifications for asphalt concrete.

(a) Type I. Submit a state department of transportation JMF approved within the past 12 months for approval at least 30 days before production. For each proposed JMF, submit a production certification conforming to state department of transportation specifications and conforming to design parameter (a), (b), or (c) for the type of mix submitted and conforming to design parameter (d) in Table 403-1.

Table 403-1
Asphalt Concrete Mix Requirements

Design Parameters	Specification
(a) Volumetric hot asphalt concrete pavement (AASHTO M 323, AASHTO R 35, and AASHTO T 312)	
Gyratory compaction level	7, 75, 115
Volumetric properties at 0.3 to 3 million ESAL's (AASHTO M 323)	See Table 401-1
(b) Hveem (AASHTO T 246 and AASHTO T 247)	
Stabilometer, minimum	35
Percent air voids (1)	3.0 – 5.0
(c) Marshall (AASHTO T 245)	
Stability, pounds (kilonewtons), minimum	2000 (8.9)
Flow, 0.01 inches (0.25 millimeters)	8 – 14
Percent air voids (1)	3.0 – 5.0
Compaction, number of blows each end of test specimen	75
(d) Moisture susceptibility (AASHTO T 283)	
Tensile strength ratio, minimum	0.80

(1) The percent of air voids are based on AASHTO T 166, AASHTO T 209 and AASHTO T 269.

(b) Type II. Provide a mix composed of crushed stone or gravel and asphalt binder mixed in an approved plant. Use an aggregate gradation and asphalt binder of a quality conforming to those normally used locally by either Federal or state agencies for the type of work being constructed.

Submit the strength, quality, and gradation specifications for the asphalt concrete mix. Include copies of laboratory test reports that demonstrate aggregate, asphalt binder, additive, and mix properties meet Federal, state or local government agency specifications.

For both Type I and Type II, submit the maximum specific gravity (density) of the mix as determined by AASHTO T 209.

403.03 Production Start-Up Procedures. See Subsection 153.04(b).

403.04 Mixing Plant. See Subsection 401.04.

403.05 Surface Preparation. See Subsection 401.06.

403.06 Weather Limitations. See Subsection 401.07.

403.07 Hauling. See Subsection 401.11.

403.08 Placing and Finishing. Do not use mixes produced from different plants unless the mixes are produced according to the same JMF, use material from the same sources, and are approved.

Place HMA at a temperature conforming to Table 401-2. Place WMA at temperatures conforming to Subsection 401.03. Measure temperature of the asphalt concrete mix in the hauling vehicle just before dumping into the spreader or measure it in the windrow immediately before pickup.

(a) Asphalt concrete for roadway construction. Place the mix with a paver conforming to Subsection 401.05. Control horizontal alignment using a reference line. Automatically control the grade and slope from reference lines, a ski and slope control device, or dual skis. Use skis having a minimum length of 20 feet (6 meters).

In areas where mechanical spreading and finishing is impractical; place and finish the asphalt concrete mix according to Subsection 403.08(b).

Offset the longitudinal joint according to Subsection 401.13.

(b) Asphalt concrete for non-roadway uses. Spread and finish each course by hand raking, screeding, or by other approved methods.

403.09 Compacting. Thoroughly and uniformly compact the asphalt surface by rolling. In places inaccessible to rollers, use alternate equipment approved by the CO. Do not cause cracking, shoving or undue displacement.

Monitor the compaction process with nuclear density gauges calibrate according to the ASTM D2950 calibration section within 6 months before use. Check the standard and reference on each day of use according to the ASTM D2950 standardization and reference check sections. Compact to at least 91.0 percent of the maximum specific gravity (density) determined in Subsection 403.02.

Continue compaction until surface marks are eliminated and cracks are sealed.

403.10 Joints, Trimming Edges, and Cleanup. See Subsection 401.15.

403.11 Pavement Straightedge Measurement. Measure the pavement surface using a 10-foot (3-meter) metal straightedge at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge in excess of ¼ inches (6 millimeters) measured between two contacts of the straightedge or deviations in excess of ¼ inches (6 millimeters) measured at the end of the straightedge.

Correct defective areas according to Subsection 401.16(g)(1) through (4). Obtain approval for the method of correction.

403.12 Acceptance. See Table 403-2 for sampling, testing, and acceptance requirements.

Asphalt concrete mix properties will be evaluated under Subsection 106.04.

Asphalt binder will be evaluated under Subsection 106.03.

Construction of asphalt concrete work will be evaluated under Subsections 106.02 and 106.04.

Pavement straightedge measurement will be evaluated under Subsection 106.04

Measurement

403.13 Measure the Section 403 pay items listed in the bid schedule according to Subsection 109.02.

Payment

403.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 403 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 403-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production								
Asphalt concrete, Type I (403.02(a))	Measured and tested for conformance (106.04)	Density [1]	AASHTO T 166	1 per 700 tons (650 metric tons)	In-place after compacting	Yes	24 hours	Deliver cores to CO after testing is completed
		Surface tolerance	Straightedge measurement, Subsection 403.11	Continuously, after compaction	Finished pavement surface	No	"	–
		Placement temperature	–	First load and as determined by CO thereafter	Hauling vehicle before dumping, or windrow before pickup	"	Upon completion of measurement	–
	Process control (153.03)	Gradation at the plant	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	"	24 hours	–
		Moisture content of aggregates	AASHTO T 255	"	Stockpile	"	"	–
		Density	ASTM D2950	1 per 500 feet (150 meters)	In-place after compacting	"	"	–
Asphalt concrete, Type II (403.02(b))	Measured and tested for conformance (106.04)	"	"	3 per 700 tons (650 metric tons)	In-place after compacting	"	"	–

(1) Dry cores to constant mass at 125±5°F (52±3 °C) or vacuum dry, ASTM D7227 before testing. For asphalt concrete Type I, cut two 6-inch (150-millimeter) diameter side by side cores. Remove them with a core retriever and fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling and temperature. Submit one core for verification testing. Dry the other core to constant mass at 125±5 °F (52±3 °C) or vacuum dry it according to ASTM D7227 before performing the core density and measuring the thickness. Use 62.245 pounds per cubic foot (997.1 kilograms per cubic meter) to convert specific gravity to density.

Section 404. — RESERVED

Section 405. — OPEN-GRADED ASPHALT FRICTION COURSE

Description

405.01 This work consists of constructing an open-graded asphalt friction course (OGFC).

Grading is designated according to Table 703-6.

Asphalt binder is designated according to AASHTO M 320.

Antistrip additive type is designated according to Subsection 702.05. Where no type is designated use Type 3 (lime).

Material

405.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Mineral filler	725.05
Open-graded asphalt friction course aggregate	703.08

Construction Requirements

405.03 Composition of Mix (JMF). Provide OGFC mixes of aggregate and asphalt binder designed according to ASTM D7064 or other approved methods that meet the applicable requirements in Table 405-1. Fabricate gyratory compacted specimens 6 inches (150 millimeter) in diameter and 4 inches (100 millimeters) nominal height. The Cantabro abrasion test is not required. Provide an application temperature range.

Table 405-1
OGFC Mix Requirements

Design Parameter	Requirement
Air voids, ASTM D3203 or D6752	18% minimum
Draindown, ASTM D6390	0.3% maximum, by mixture mass
Moisture susceptibility, AASHTO T 283, except as modified by ASTM D7064	80% minimum

(a) Submission. Submit a written JMF, mix design reports, applicable charts, and design data for verification at least 30 days before production. Include a signed statement prepared by the testing laboratory that certifies the proposed JMF meets requirements. For the proposed JMF, submit the following:

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each specified sieve size for the aggregate blend; and

(2) Set target values within the gradation ranges shown in Table 703-6 for the required grading.

(b) Source and percentage of each stockpile to be used;

(c) Average gradation of each stockpile;

(d) Representative samples from each stockpile. Use split samples of material taken at the same time samples are taken for testing by the Contractor's laboratory.

(1) 200 pounds (90 kilograms) of aggregates proportioned by each stockpile according to the JMF; and

(2) 5 pounds (2 kilograms) of mineral filler, if proposed for the JMF.

(e) Results of aggregate quality tests performed within 1 year of use. For aggregate quality tests, see Subsection 703.08.

(2) Asphalt binder. See Subsection 401.03(c)(2).

(3) Antistrip additives. See Subsection 401.03(c)(3).

(b) Verification. The verification process starts when required documentation and material are received. Do not begin OGFC production until the JMF is verified.

(1) Aggregate gradations. The Contractor's aggregate gradation is verified if the CO's gradation on a combined OGFC mix using the Contractor's aggregate stockpile percentage recommendations is within the Contractor's target value gradation plus or minus the following tolerance for each sieve:

Sieve Size	Tolerance, % (±)
No. 4 (4.75 mm)	3.0
No. 8 (2.36 mm)	3.0
No. 200 (75 µm)	1.0

(2) Moisture susceptibility. The Contractor's retained tensile strength result determined by AASHTO T 283, except as modified by ASTM D7064; is verified if the CO's result is 80 percent minimum.

(c) Changes and resubmissions. If a JMF is rejected or the source of material is changed, submit a new JMF for verification. Up to 14 days may be required to evaluate a change after receipt of required documentation and material. Approved changes in target values will not be applied retroactively for payment.

The CO will deduct JMF evaluation costs resulting from the following:

(1) Contractor-requested changes to the approved JMF and

(2) Additional testing necessary due to the failure of a submitted JMF.

405.04 Mixing Plant. See Subsection 401.04.

405.05 Pavers. See Subsection 401.05(a).

405.06 Surface Preparation. See Subsection 401.06.

405.07 Weather Limitations. Place the OGFC mix on a dry asphalt surface when the air temperature in the shade is above 55 °F (13 °C) and the road surface temperature is above 60 °F (16 °C). Stop placement if either temperature falls below these minimums.

405.08 Preparing and Mixing Material. Prepare, mix, and control material according to Subsections 401.08 through 401.10, except do not heat the aggregate introduced into the mixer above the optimum mixing temperature established in the JMF.

405.09 Hauling, Placing, and Finishing. Haul, place, and finish the mix according to Subsections 401.11 and 401.13. Place the mix within the approved temperature range. Minimize asphalt binder drainage by discharging the mix into the paver within 1½ hours of loading the truck. When surge bins are used, begin this 1½-hour limit at the time the mix is deposited into the surge bin.

405.10 Compacting. Roll the OGFC mix before the mix temperature drops below 200 °F (93 °C) or the temperature recommended by the asphalt binder manufacturer. Use a steel-wheeled roller for compacting the mix. Do not shove, distort, or strip the mix beneath the roller. Roll the mix parallel to the centerline, commencing at the outside edge and progressing towards the center. On superelevated curves, begin the rolling on the low side and progress to the high side. Limit rolling to that necessary to consolidate the OGFC and bond it to the underlying surface.

405.11 Joints and Cleanup. Use butt joints for longitudinal and transverse joints. Protect the completed OGFC from traffic until it has sufficiently hardened to resist abrasion, pickup, and raveling.

Dispose of material trimmed from the edges and other discarded asphalt concrete mix according to Subsection 211.02(a)(2).

405.12 Straightedge Measurement. See Subsection 403.11.

405.13 Acceptance. See Table 405-2 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler and antistrip additive will be evaluated under Subsections 106.02 and 106.03.

Asphalt binder will be evaluated under Subsections 106.03 and 106.04.

Asphalt content and aggregate gradation will be evaluated under Subsection 106.05. Evaluations will consider the following:

(a) Asphalt content. The upper and lower specification limits are the approved JMF target value plus or minus 0.4 percent.

(b) Aggregate gradation. The upper and lower specification limits are the approved JMF target values plus or minus the allowable deviations shown in Table 703-5.

Construction of open-graded asphalt friction course will be evaluated under Subsections 106.02 and 106.04.

Measurement

405.14 Measure the Section 405 pay items listed in the bid schedule according to Subsection 109.02.

Payment

405.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 405 pay items listed in the bid schedule, except the OGFC contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for OGFC will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is the lowest single pay factor determined for asphalt content or any individual sieve of the aggregate gradation.

Table 405-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
OGFC aggregate (703.08)	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsection 703.08	1 per type and source of material	Source of material	Yes	Before production	Not required when using Government-provided source
Asphalt binder (702.01)	"	Quality	–	AASHTO M 320	"	Asphalt supplier or mixing plant	"	"	–
Mix Design									
OGFC asphalt concrete mixture	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	30 days before producing	–
		Air voids	–	ASTM D3203 or D6752	"	–	"	"	–
		Draindown	–	ASTM D6390	"	–	"	"	–
		Tensile strength ratio	–	AASHTO T 283	"	–	"	"	Complete AASHTO T 283, except as modified by ASTM D7064

Table 405-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
OGFC	Statistical (106.05)	Asphalt content	I	AASHTO T 308	1 per 300 tons (300 metric ton)	Point of discharge of the mixing unit	Yes	24 hours	–
		Gradation (at paver)		AASHTO T 30	"	"	"	"	–
		No. 4 (4.75 µm)	I						
		No. 200 (75 µm)	I						
		Other specified sieves	II						
	Measured and tested for conformance (106.04)	Placement and compaction temperature	–	–	First load and as determined by CO thereafter	Hauling vehicle before dumping, or windrow before pickup and pavement surface during rolling	No	Upon completion of measurement	–
Asphalt binder (702.01)	"	Quality	–	Subsection 702.01	1 per 1000 tons (900 metric tons) of mix	In line between tank & mixing plant	Yes, 2 1-quart (1-liter) samples	–	Test by Government

Table 405-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
OGFC	Process control (153.03)	Gradation at plant	–	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	No	24 hours	–
		Moisture content of aggregates	–	AASHTO T 255	"	Stockpile	"	"	–
Finished Product									
OGFC	Measured and tested for conformance (106.04)	Surface tolerance	–	Straightedge measurements, Subsection 403.11	Continuously, after compaction	Finished pavement surface	No	24 hours	–

Section 406. — FOG SEAL

Description

406.01 This work consists of applying an emulsified asphalt fog seal.

Emulsified asphalt is designated according to AASHTO M 140 or AASHTO M 208.

Material

406.02 Conform to the following Subsections:

Blotter	703.12
Emulsified asphalt	702.02
Water	725.01(c)

Construction Requirements

406.03 Equipment. Furnish an asphalt distributor with the following:

(a) Heater for uniformly heating the asphalt;

(b) Full circulation spray bar adjustable to 15-foot (4.5-meter) width;

(c) Positive controls including tachometer, pressure gauge, volume measuring device, or calibrated tank to uniformly deposit asphalt over the full width within 0.02 gallons per square yard (0.09 liters per square meter) of the required rate; and

(d) Thermometer for measuring asphalt temperature in the tank.

406.04 Surface Preparation.

(a) Clean the existing surface of loose material, dirt, and other deleterious material before placing the fog seal. Remove or protect raised pavement markers, pavement markings, reflectorized tape, and other material that interferes with the work. Protect service entrances (such as manholes, valve boxes, and drop inlets). Protect concrete work, rock walls, and other objects adjacent to the work.

(b) Dry the surface before placing the fog seal.

406.05 Weather Limitations. Apply fog seals only when the following apply:

(a) Ambient air temperature is above 50 °F (10 °C);

(b) Surface temperature is above 50 °F (10 °C);

(c) Weather is not foggy or rainy;

(d) Rain or temperatures below 40 °F (4 °C) are not anticipated for at least 24 hours after application;

(e) Sustained winds are less than or equal to 10 miles (16 kilometers) per hour; and

(f) Application is completed at least 2 hours before sunset.

406.06 Asphalt Application. Dilute the emulsion one part water to one part emulsified asphalt.

Apply the emulsion according to Subsection 407.09 at a rate of 0.10 to 0.15 gallons per square yard (0.4 to 0.7 liters per square meter) as approved by the CO.

At locations where the fog seal cannot be applied with an asphalt distributor spray bar, apply the fog seal uniformly using a hand spray attachment or by another approved method.

Allow the fog seal to cure undisturbed for at least 2 hours or until the emulsified asphalt breaks and is substantially tack free.

Cover unabsorbed asphalt with blotter to protect traffic or minimize rain damage. Remove excess blotter after the asphalt is absorbed. Dispose of material according to Subsection 203.05(a) and (d).

406.07 Acceptance. See Table 406-1 for sampling, testing, and acceptance requirements.

Emulsified asphalt will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each load of emulsified asphalt.

Blotter will be evaluated under Subsection 106.03.

Construction of fog seals will be evaluated under Subsections 106.02 and 106.04.

Measurement

406.08 Measure the Section 406 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure fog seal including water added for dilution. Show a breakdown of total emulsion and water added on the load invoices supplied to the CO for payment.

Payment

406.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 406 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 406-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Emulsified asphalt (702.02)	Process control (153.03)	Placement temperature	–	–	Minimum 1 per distributor truck	Distributor truck	No	Before incorporating into work	–

Section 407. — CHIP SEAL

Description

407.01 This work consists of applying a single or double course chip seal.

Chip seal types are designated according to Tables 407-1 and 407-2.

Asphalt binder is designated according to AASHTO M 320 and emulsified asphalt is designated according to AASHTO M 140 or AASHTO M 208.

Material

407.02 Conform to the following Section and Subsections:

Asphalt binder	702.01
Blotter	703.12
Chip seal aggregate	703.09
Emulsified asphalt	702.02
Fog seal	406

Construction Requirements

407.03 Qualifications. Provide a superintendent and foreman with experience in placing chip seals. Submit the following for approval at least 14 days before starting chip seal work:

(a) Names of personnel; and

(b) A résumé for each individual describing their experience on at least five chip seal projects of similar complexity.

407.04 Composition. Submit the following for approval at least 14 days before placement:

(a) Aggregate samples. 80 pounds (35 kilograms) from the material produced for the project, the gradation range represented, and the proposed target value for each sieve size;

(b) Asphalt sample. 1-gallon (4-liter) sample with a production certification conforming to Subsection 106.03(a);

(c) Spread rates. The proposed spread rate for the asphalt and aggregate; and

(d) Density. The density of the aggregate according to AASHTO T 19, shoveling procedure.

407.05 Equipment.

(a) Asphalt distributor. See Subsection 406.03. Maintain two-way radio communication with the aggregate spreader.

(b) Sweeper. Furnish two sweepers conforming to Subsection 409.05(c).

(c) Pneumatic-tire rollers.

(1) Three rollers each with a minimum compacting width of 5 feet (1.5 meters), or two rollers each with a minimum compacting width of 6.5 feet (2.0 meters); and

(2) Gross mass adjustable within the range of 200 to 360 pounds per inch (3.6 to 6.4 kilograms per millimeter) of compaction width.

(d) Aggregate spreader. Controls to uniformly deposit aggregate over the full asphalt width.

407.06 Surface Preparation. See Subsection 406.04(a). Prepare the surface as follows:

(a) Newly asphalt patched areas. Fog seal according to Section 406.

(b) Existing asphalt surfaces including recycled asphalt pavements. Dry the surface.

(c) Aggregate base course surfaces.

(1) When using an emulsified asphalt, make the surface damp; or

(2) When using an asphalt binder, dry the surface.

407.07 Weather Limitations. Apply chip seals only when the following apply:

(a) Ambient air temperature is above 65 °F (18 °C);

(b) Surface temperature in the shade is above 60 °F (16 °C);

(c) Surface temperature in the sun is below 150 °F (66 °C);

(d) Weather is not foggy or rainy;

(e) Rain or temperatures below 40 °F (4 °C) are not anticipated for at least 24 hours after application;

(f) Sustained winds are less than or equal to 10 miles (16 kilometers) per hour; and

(g) Application is completed at least 2 hours before sunset.

407.08 Production Start-Up Procedures. Conduct a pre-chip seal preparatory phase meeting according to Subsection 153.04(a).

On the first day of each chip seal layer placement, construct up to three 200- to 500-foot (60- to 150-meter) control strips that are one-lane wide according to Subsections 407.09 and 407.10. Coordinate the control strip locations with the CO. Start the first control strip at the proposed application rates. Vary the asphalt material or surface aggregate application rate for each control strip. Construct the control strip using the material, lay-down procedures, and compaction procedures intended for the entire project.

Repeat the control strip process until an acceptable control strip is produced. Cease production until the material and the control strip are evaluated and accepted. The CO will indicate which strip will serve as the approved project control strip.

Acceptable control strips may remain in place and will be accepted as a part of the completed project. Correct unacceptable control strips.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the beginning of a new construction season.

407.09 Asphalt Application. Calibrate asphalt distributors before the start of project and when directed by the CO. Calibrate the spray bar height, check nozzle angle, and verify longitudinal and transverse application rates according to ASTM D2995.

Spread building paper on the pavement surface at the beginning and end of each asphalt application so distributor flow is started and stopped on the paper.

Apply asphalt uniformly at the optimum application rate determined from the control strip. Do not apply more asphalt than can immediately be covered with aggregate. Correct skipped areas or deficiencies.

At the end of each day's production, provide the CO with documentation of calibrations and application rates.

Remove and dispose of material spills and associated debris at the end of each shift according to Subsection 203.05(a) and (d).

407.10 Aggregate Application. When emulsified asphalt is used, verify the aggregate stockpile moisture daily and use moist surfaced aggregate.

When asphalt binder is used, dry the aggregate. Precoat the aggregate uniformly with 2 to 3 percent of residual asphalt by mass of aggregate. Maintain the flow qualities of the precoated aggregate to allow uniform spreading with the aggregate spreader.

Calibrate aggregate spreaders before the start of project and as directed by the CO. Calibrate the longitudinal and transverse spread rates.

Apply aggregate uniformly at the optimum application rate determined from the approved control strip. Apply the aggregate immediately after the asphalt material is applied. Operate the aggregate spreader so asphalt is covered with the aggregate before wheels pass over it. For part-width construction, leave an uncovered 6-inch (150-millimeter) wide asphalt strip to permit an overlap of asphalt material.

Cover excess asphalt with blotter to protect traffic.

Correct excesses and deficiencies by adding or removing aggregate to achieve a uniform texture before the asphalt cures.

Operate rollers at a maximum speed of 5 miles (8 kilometers) per hour. Do not allow the aggregate to be displaced by pickup or sticking of material to the tire surface. Roll the surface to uniformly and thoroughly bond the aggregate over the full width. Complete rolling within 1 hour after asphalt is applied to the surface. Perform three passes with the rollers. Do not allow traffic to travel over aggregate until rolling is completed.

At the end of each day's production, provide the CO with documentation for calibrations and application rates.

Use a pilot car according to Section 635 to limit traffic speeds to 10 miles (15 kilometers) per hour during the first 45 minutes after rolling and to 20 miles (30 kilometers) per hour for the next 24 hours.

Sweep the surface when the air temperature is below 90 °F (32 °C). Do not displace embedded material. Complete vacuum sweeping by the morning after construction. Dispose of material according to Subsection 203.05(a) and (d).

407.11 Placing and Finishing. Apply the asphalt and aggregate according to Subsections 407.09 and 407.10 and Table 407-1. The application rates in these tables are for estimating purposes only. Determine the exact rates based on approved control strips.

Table 407-1
Approximate Quantities of Material for Single Course Chip Seal

Type	Nominal Maximum Size of Aggregate	Aggregate Gradation(1)	Estimated Quantity of Aggregate (2) pounds/yd^2 (kilograms/m^2)	Estimated Quantity of Asphalt Binder gallons/yd^2 (liters/m^2)	Estimated Quantity of Emulsified Asphalt gallons/yd^2 (liters/m^2)
1A	¾ inch (19 mm)	A	44 – 53 (24 – 29)	0.31 – 0.42 (1.41 – 1.91)	0.48 – 0.65 (2.17 – 2.94)
1B	½ inch (12.5 mm)	B	29 – 33 (16 – 18)	0.25 – 0.34 (1.15 – 1.56)	0.39 – 0.53 (1.77 – 2.40)
1C	⅜ inch (9.5 mm)	C	24 – 28 (13 – 15)	0.18 – 0.28 (0.79 – 1.27)	0.27 – 0.43 (1.22 – 1.95)
1D	No. 4 (4.75 mm)	D	18 – 24 (10 – 13)	0.14 – 0.19 (0.65 – 0.85)	0.27 – 0.43 (1.22 – 1.95)

(1) See Table 703-7 for aggregate gradations.

(2) Aggregate masses are for aggregates having a bulk specific gravity of 2.65, as determined by AASHTO T 84 and AASHTO T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.

407.12 Double Course Chip Seal. Apply each asphalt and aggregate layer according to Subsections 407.09 and 407.10 and Table 407-2. Table 407-2 application rates are for estimating purposes only. Determine the exact rates based on approved control strips.

When using emulsified asphalt, wait at least 24 hours between applications. When using asphalt binder, no wait is required between applications. Lightly vacuum sweep the first layer to remove loose material.

Table 407-2
Approximate Quantities of Material for Double Course Chip Seal

Type (Thickness)	Nominal Maximum Size of Aggregate	Aggregate Gradation(1)	Estimated Quantity of Aggregate (2) pounds/yd^2 (kilograms/m^2)	Estimated Quantity of Asphalt Binder gallons/yd^2 (liters/m^2)	Estimated Quantity of Emulsified Asphalt gallons/yd^2 (liters/m^2)
2A (⅞ inch (22 mm))					
1st Application	¾ inch (19 mm)	A	44 – 53 (24 – 29)	0.29 – 0.41 (1.31 – 1.86)	0.43 – 0.60 (1.95 – 2.72)
2nd Application	⅜ inch (9.5 mm)	C	24 – 29 (13 – 16)	0.41 – 0.46 (1.86 – 2.08)	0.60 – 0.70 (2.72 – 3.17)
2B (¾ inch (19 mm))					
1st Application	½ inch (12.5 mm)	B	33 – 44 (18 – 24)	0.27 – 0.31 (1.22 – 1.40)	0.39 – 0.48 (1.77 – 2.17)
2nd Application	⅜ inch (9.5 mm)	C	22 – 26 (12 – 14)	0.29 – 0.38 (1.31 – 1.72)	0.45 – 0.58 (2.04 – 2.63)
2C (½ inch (12.5 mm))					
1st Application	⅜ inch (9.5 mm)	C	29 – 39 (16 – 21)	0.17 – 0.27 (0.77 – 1.22)	0.27 – 0.39 (1.22 – 1.77)
2nd Application	No. 4 (4.75 mm)	D	13 – 18 (7 – 10)	0.27 – 0.31 (1.22 – 1.40)	0.39 – 0.48 (1.77 – 2.17)

(1) See Table 703-7 for aggregate gradations.

(2) Aggregate masses are for aggregates having a bulk specific gravity of 2.65, as determined by AASHTO T 84 and AASHTO T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.

407.13 Acceptance. See Table 407-3 for sampling, testing, and acceptance requirements.

Emulsified asphalt and asphalt binder will be evaluated under Subsections 106.03 and 106.04. Furnish a production certification with each load of emulsified asphalt or asphalt binder.

Chip seal aggregate gradation will be evaluated under Subsection 106.05.

The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Table 703-7, except as follows:

(a) If the calculated mean value for a tested sieve exceeds the maximum gradation value shown in Table 703-7, the upper specification is equal to the maximum gradation value plus the allowable deviation, and the lower specification is equal to the maximum gradation value minus the allowable deviation.

(b) If the calculated mean value for a tested sieve is less than the minimum gradation value shown in Table 703-7, the upper specification is equal to the minimum gradation value plus the allowable deviation, and the lower specification is equal to the minimum gradation value minus the allowable deviation.

Construction of asphalt chip seals will be evaluated under Subsections 106.02 and 106.04.

Measurement

407.14 Measure the Section 407 pay items listed in the bid schedule according to Subsection 109.02.

Payment

407.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 407 pay items listed in the bid schedule, except the chip seal contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for the chip seal will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is the lowest single pay factor determined for each specified sieve of the aggregate gradation for each aggregate gradation furnished.

When two gradations are furnished for a double chip seal the material pay factor is weighted for the quantity of each aggregate gradation spread as a percent of the total. The material pay factor is calculated as follows:

$$PF_{Material} = PF_{1st}[SR_{1st}/(SR_{1st} + SR_{2nd})] + PF_{2nd}[SR_{2nd}/(SR_{1st} + SR_{2nd})]$$

where:

$PF_{Material}$ = Material pay factor.

PF_{1st} = Pay factor for first aggregate gradation. PF_{1st} is the lowest single pay factor determined for each specified sieve.

PF_{2nd} = Pay factor for second aggregate gradation. PF_{2nd} is the lowest single pay factor determined for each specified sieve.

SR_{1st} = Spread rate for the first aggregate per square yard (square meter).

SR_{2nd} = Spread rate for the second aggregate per square yard (square meter).

Table 407-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)[3]	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Chip seal aggregate [1]	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsection 703.09	1 per material type	Source of material	Yes	Before producing	–
	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required when using a pre-crushed commercial source
Blotter	"	"	–	Subsection 703.12	"	"	"	"	–
Asphalt binder [2] or emulsified asphalt [2]	Measured and tested for conformance (106.04)	Quality	–	Section 702	1 per material type	Point of shipment or delivery	Yes [5]	Before incorporating into work	–

Table 407-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection) [3]	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Chip seal aggregate [1]	Statistical[3] (106.05)	Gradation (See Table 703-7 for applicable sieves	I	AASHTO T 27 & T 11	See Note (3)	Production belt or spreader discharge[4]	Yes	24 hours	–
	Process control (153.03)	Moisture on surface of aggregates	–	Visual inspection (409.10)	Contractor determine	Stockpile or spreader discharge	No	Before incorporating into work	–
Asphalt binder [2] or emulsified asphalt [2]	Measured and tested for conformance (106.04)	Quality	–	Section 702	1 per tanker truck including trailer	Tanker or Distributor	Yes [5]	–	Tested by Government
	Process control (153.03)	Placement temperature	–	–	Minimum 1 per distributor truck	Distributor truck	No	Before incorporating into work	–

(1) Applies to each aggregate grade furnished.

(2) Applies to each asphalt material furnished.

(3) For plan quantities less than 40,000 square yards (33,000 square meters), material will be accepted according to Subsection 106.03. For plan quantities greater than 40,000 square yards (33,000 square meters), material will be accepted according to Subsection 106.05.For plan quantities between 40,000 and 240,000 square yards (33,000 and 200,000 square meters), the sampling frequency will be determined by dividing the plan quantity by eight. If plan quantity exceeds 240,000 square yards (200,000 square meters), the sampling frequency will be one every 30,000 square yards (25,000 square meters).

(4) Select one point of sampling that must remain throughout project or lot.

(5) Two 1-quart (1-liter) samples for asphalt binder. One 1-gallon (4-liter) sample for emulsified asphalt.

Section 408. — RESERVED

Section 409. — MICRO SURFACING

Description

409.01 This work consists of applying a polymer-modified micro surfacing mix on an existing pavement surface.

Material

409.02 Conform to the following Subsections:

Micro surfacing aggregate	703.10(b)
Mineral filler	725.05
Polymer-modified emulsified asphalt for micro-surfacing	702.02(b)
Water	725.01(c)

Construction Requirements

409.03 Qualifications. See Subsection 407.03.

409.04 Composition of Mix (JMF). Submit a written JMF for micro surfacing which conforms to ISSA A143, *Recommended Performance Guideline for Micro Surfacing* for approval at least 14 days before production. Include the following:

(a) Aggregate gradation values. Percent passing for each sieve size for the aggregate blend;

(b) Emulsified asphalt content. Residual asphalt content, as a percent by mass of dry aggregate;

(c) Polymer-modifier. Type and quantity of polymer-modifier solids based on the residual asphalt content;

(d) Aggregate samples. 80-pound (35-kilogram) sample of each aggregate;

(e) Polymer-modified emulsified asphalt sample. 1-gallon (4-liter) sample with a production certification conforming to Subsection 106.03(a); and

(f) Mineral filler samples. 10-pound (5 kilogram) sample of each proposed mineral filler.

409.05 Equipment.

(a) Mixing equipment. Conform to ISSA A143.

(b) Spreading equipment. Conform to ISSA A143 with the exception that augers within the spreader box are not required.

(c) Sweeper.

(1) Self-propelled;

(2) Vertical broom pressure control; and

(3) Vacuum capability.

(d) Pneumatic-tire rollers.

(1) Self-propelled;

(2) 10-ton (9-metric ton) gross mass with a tire pressure of 50 pounds per square inch (350 kilopascals); and

(3) Water-spray system.

(e) Auxiliary equipment. Furnish hand squeegees, shovels, and other equipment necessary to perform the work. Provide power brooms, air compressors, water flushing equipment, and hand brooms to clean the pavement surface.

Other equipment of proven performance may be used in addition to or instead of this equipment when approved by the CO.

409.06 Surface Preparation. See Subsection 406.04(a).

409.07 Weather Limitations. Apply only when the following apply:

(a) Ambient air temperature is above 45 °F (7 °C);

(b) Surface temperature in the shade is above 45 °F (7 °C);

(c) Weather is not foggy, rainy, or overcast;

(d) Rain or temperatures below 32 °F (0 °C) are not anticipated for at least 24 hours after application.

409.08 Calibration. Calibrate mixing equipment according to ISSA A143.

409.09 Production Start-Up Procedures. Conduct a pre-surfacing preparatory phase meeting according to Subsection 153.04(a).

On the first day of placement, construct one 300-foot (100-meter) long control strip, one lane wide. Coordinate location of the control strip with the CO. Construct the control strip using material, lay-down, and rolling procedures intended for the entire project.

Cease production after construction of the control strip until the material and the control strip are evaluated and accepted by the CO. Repeat the control strip process until an acceptable control strip is produced.

Acceptable control strips may remain in place and will be accepted as a part of the completed surface treatment. Correct unacceptable control strips.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the beginning of a new construction season.

409.10 Application. Fog the surface with water in front of the spreader.

Blend the additives with the aggregate. Pre-wet the aggregate in the pugmill before mixing with the polymer-modified emulsified asphalt.

Mix the surfacing material a maximum of 4 minutes. Ensure the mix is of uniform consistency as it leaves the mixer and conforms to the approved JMF. Adjust mineral filler and polymer-modified emulsified asphalt content during construction when approved by the CO to adjust for variations in field conditions.

Clean the spreader box before the start of each work shift.

Carry sufficient mix in the spreader to completely cover the surface. Spread the mix with a spreader box. In areas not accessible to the spreader use hand squeegees to work the mix.

Remove streaks and transverse ripples as defined by ISSA A143 from the finished surface.

Provide straight lines along curbs and shoulders and do not allow runoff onto these areas. Provide straight and neat starting and ending joints by masking surfaces at the start, end, and other locations as directed by the CO.

For transverse joints, use a butt joint. Use building paper placed over previously placed micro surfacing or other suitable method to avoid double placement of micro surfacing. Remove ridges or bumps in the finished surface.

For longitudinal joints, place joints on lane lines. Use half passes and odd-width passes only in turnouts and parking areas. Do not use half passes for the last pass in paved areas. Overlap longitudinal joints no more than 3 inches (75 millimeters). Limit the elevation difference at joints to less than ¼ inch (6 millimeters).

Begin rolling after the mixture has cured to the point where it will not pick up on the roller tires. Roll parking areas and turnouts with at least two full-coverage passes with the roller. Rolling the mainline roadway is not required.

Allow treated areas to cure completely before opening to traffic. Cure is complete when clear water can be pressed out of the placed mix with a piece of paper without discoloring the paper.

Remove and dispose of material spills and associated debris at the end of each shift according to Subsection 203.05(a) and (d).

Two weeks to one month after completion of micro surfacing application, sweep the entire treated surface. Dispose of swept material according to Subsection 203.05(a).

409.11 Acceptance. See Table 409-1 for sampling, testing, and acceptance requirements.

Polymer-modified emulsified asphalt will be evaluated under Subsections 106.03 and 106.04. Furnish a production certification with each load of polymer-modified emulsified asphalt.

Micro surfacing aggregate will be evaluated under Subsections 106.02 and 106.04.

Mineral filler will be evaluated under Subsections 106.02 an 106.03.

Construction of the micro surfacing will be evaluated under Subsections 106.02 and 106.04.

Measurement

409.12 Measure the Section 409 pay items listed in the bid schedule according to Subsection 109.02 for each day's production.

Payment

409.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 409 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 409-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Micro surfacing aggregate for surface mixture[(1)]	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsection 703.10	1 per material type	Source of material	Yes	Before producing	–
	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required when using a pre-crushed commercial source
Polymer-modified emulsified asphalt[(2)]	Measured and tested for conformance (106.04)	Quality	–	Subsection 702.02	1 per material type	Point of shipment or delivery	Yes, 2 1-quart (1-liter) samples	Before incorporating into work	–

Table 409-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Micro surfacing aggregate for surface mixture (1)	Measured and tested for conformance (106.04)	Gradation (See Table 703-8 for applicable sieves)	–	AASHTO T 27 & T 11	1 per 50,000 yd^2 (40,000 m^2)	Stockpile	Yes	24 hours	–
Polymer-modified emulsified asphalt (2)	Measured and tested for conformance (106.04)	Quality	–	Subsection 702.02(b)	1 per day	Point of shipment or delivery	Yes, 2 1-quart (1-liter) samples	–	Tested by Government
	Process control (153.03)	Placement temperature	–	–	Minimum 1 per distributor truck	Distributor truck	No	Before incorporating into work	–

(1) Applies to each aggregate grade furnished.

(2) Applies to each asphalt material furnished.

Section 410. — SLURRY SEAL

Description

410.01 This work consists of applying an emulsified asphalt slurry seal mix on a pavement surface.

Material

410.02 Conform to the following Subsections:

Emulsified asphalt	702.02
Mineral filler	725.05
Slurry seal aggregate	703.10(a)
Water	725.01(c)

Construction Requirements

410.03 Qualifications. See Subsection 407.03.

410.04 Composition of Mix (JMF). Submit a written JMF for asphalt slurry seal which conforms to ISSA A105, *Recommended Performance Guideline for Emulsified Asphalt Slurry Seal* for approval at least 30 days before production. Include the following:

(a) Aggregate gradation values. Percent passing for each sieve size for the aggregate blend;

(b) Emulsified asphalt content. Residual asphalt content, as a percent by mass of dry aggregate;

(c) Aggregate samples. 80-pound (35-kilogram) sample of each aggregate;

(d) Emulsified asphalt sample. 1-gallon (4-liter) sample with a production certification conforming to Subsection 106.03(a); and

(e) Mineral filler samples. 10-pound (5-kilogram) sample of each proposed mineral filler.

410.05 Equipment.

(a) Mixing equipment. Conform to the requirements of ISSA A105.

(b) Mechanical-type single squeegee spreader box.

(1) Attaches to the mixer;

(2) Flexible squeegee in contact with the pavement surface to prevent loss of material;

(3) Adjustable to ensure a uniform spread over varying grades and crowns;

(4) Adjustable in width with a flexible strike-off; and

(5) Augers for uniform flow to edges.

(c) Sweeper. See Subsection 409.05(c).

(d) Pneumatic-tire rollers. See Subsection 409.05(d).

(e) Auxiliary equipment. See Subsection 409.05(e).

Other equipment of proven performance may be used in addition to or instead of this equipment when approved by the CO.

410.06 Surface Preparation. See Subsection 406.04(a).

410.07 Weather Limitations. See Subsection 409.07.

410.08 Calibration. Calibrate each mixing unit according to ISSA A105 in the presence of the CO.

410.09 Production Start-Up Procedures. See Subsection 409.09.

410.10 Application. Mix the material according to ISSA A105. Fog the surface with water in front of the spreader.

Blend the additives with the aggregate. Pre-wet the aggregate in the pugmill before mixing with the emulsified asphalt.

Mix the surfacing material a maximum of 4 minutes. Ensure the mix is of uniform consistency as it leaves the mixer and conforms to the approved JMF. Adjust mineral filler and emulsified asphalt content during construction when approved by the CO to adjust for variations in field conditions.

Clean the spreader box before the start of each work shift.

Carry sufficient mix in the spreader to completely cover the surface. Spread the mix with a mechanical-type single squeegee spreader box. In areas not accessible to the spreader box, use hand squeegees to work the mix.

Remove streaks and transverse ripples as defined by ISSA A105 from the finished surface.

Provide straight lines along curbs and shoulders and do not allow runoff on these areas. Provide straight and neat starting and ending joints by masking surfaces at the start, end, and other locations as directed by the CO.

For transverse joints, use a butt joint. Use building paper placed over previously placed slurry seal or other suitable method to avoid double placement of slurry seal. Remove ridges or bumps in the finished surface.

For longitudinal joints, place joints on lane lines. Use half passes and odd-width passes only in turnouts and parking areas. Do not use half passes for the last pass in paved areas. Overlap longitudinal joints no more than 3 inches (75 millimeters). Limit the elevation difference at joints to less than ¼ inch (6 millimeters).

Begin rolling after the mixture has cured to the point where it will not pick up on the roller tires. Roll parking areas and turnouts with at least two full-coverage passes with the roller.

Allow treated areas to cure completely before opening to traffic. Cure is complete when clear water can be pressed out of the mix with a piece of paper without discoloring the paper.

Remove and dispose of material spills and associated debris at the end of each shift according to Subsection 203.05(a) and (d).

Two weeks to one month after completion of slurry seal application. Sweep and pick up the loose material from the entire treated surface. Dispose of swept material according to Subsection 203.05(a).

410.11 Acceptance. See Table 410-1 for sampling, testing, and acceptance requirements.

Emulsified asphalt will be evaluated under Subsections 106.03 and 106.04. Furnish a production certification with each load of emulsified asphalt.

Slurry seal aggregate will be evaluated under Subsections 106.02 and 106.04.

Mineral filler will be evaluated under Subsections 106.02 an 106.03.

Construction of the slurry seal will be evaluated under Subsections 106.02 and 106.04.

Measurement

410.12 Measure the Section 410 pay items listed in the bid schedule according to Subsection 109.02 for each day's production.

Payment

410.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 410 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 410-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate for surface mixture [(1)]	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsection 703.10	1 per material type	Source of material	Yes	Before producing	–
	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required when using a pre-crushed commercial source
Emulsified Asphalt [(2)]	Measured and tested for conformance (106.04)	Quality	–	Subsection 702.02	1 per material type	Point of shipment or delivery	Yes, 2 1-quart (1-liter) samples	Before incorporating into work	–

Table 410-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Aggregate for surface mixture (1)	Measured and tested for conformance (106.04)	Gradation. See Table 703-8 for applicable sieves	–	AASHTO T 27 & T 11	1 per 50,000 yd^2 (40,000 m^2)	Stockpile	Yes	24 hours	–
Emulsified asphalt (2)	"	Quality	–	Subsection 702.02	1 per day	Point of shipment or delivery	Yes, 2 1-quart (1-liter) samples	–	Tested by Government
	Process control (153.03)	Placement temperature	–	–	Minimum 1 per distributor truck	Distributor truck	No	Before incorporating into work	–

(1) Applies to each aggregate grade furnished.
(2) Applies to each asphalt material furnished.

Section 411. — ASPHALT PRIME COAT

Description

411.01 This work consists of applying a emulsified asphalt prime coat.

Prime coat asphalt grade is designated according to AASHTO M 140 or AASHTO M 208 for emulsified asphalts or Subsection 702.02(c) for penetrating emulsified asphalt.

Asphalt application is designated in Subsection 411.06. If no application method is designated, use Method 1.

Material

411.02 Conform to the following Subsections:

Blotter	703.12
Crushed aggregate	703.06
Emulsified Asphalt	702.02
Penetrating emulsified asphalt for prime coat	702.02(c)
Water	725.01(c)

Construction Requirements

411.03 Equipment. Use equipment conforming to Subsection 407.05.

411.04 Surface Preparation. Prepare the surface to be primed according to Subsection 301.06. When required, use sweeping or other approved method to remove loose dust and fine material and lightly spray the surface with water.

411.05 Weather Limitations. Apply prime coat only when the following apply:

(a) Surface is dry or slightly damp;

(b) Ambient air temperature is above 50 °F (10 °C) and rising;

(c) Surface temperature in the shade is above 50 °F (10 °C) and rising; and

(d) Weather is not foggy or rainy.

411.06 Asphalt Application. Apply emulsified asphalt according to Subsection 407.09.

(a) Method 1 (topical). Apply undiluted emulsified asphalt formulated as a penetrating prime coat at a rate of 0.10 to 0.30 gallons per square yard (0.45 to 1.35 liters per square meter). Exact application rate will be approved by the CO.

(b) Method 2 (inverted prime). Apply undiluted emulsified asphalt at a rate of 0.20 to 0.30 gallons per square yard (0.90 to 1.35 liters per square meter). Immediately apply crushed aggregate at a uniform rate of 20 to 25 pounds per square yard (10.9 to 13.6 kilograms per square meter) using an aggregate spreader. Exact application rate will be approved by the CO.

Leave a 6-inch (150-millimeter) wide uncovered strip of asphalt to permit an overlap of asphalt material during part-width construction.

Do not allow the wheels of the aggregate spreader to come in contact with the asphalt. Immediately seat the aggregate using a roller. Operate rollers at a maximum speed of 5 miles (8 kilometers) per hour.

(c) Method 3 (processed). Scarify the surface to a depth of 2 to 3 inches (50 to 75 millimeters) before applying the asphalt as a prime coat. Apply emulsified asphalt at an undiluted rate of 0.25 gallons per square yard per inch (1.10 liters per square meter per 25 millimeters) of scarification depth. Immediately process, re-spread, and compact the material. When required, dilute a slow-setting emulsified asphalt by adding water. Other methods of incorporating asphalt into the aggregate may be used when approved by the CO.

411.07 Curing. Cure surfaces primed with emulsified asphalt for at least 24 hours before covering with the next course.

411.08 Maintenance. Maintain the primed surface by keeping it free of corrugations, potholing, and loose material until the next course is placed. Remove dirt or other deleterious material and repair damaged areas.

Spread additional blotter to cover unabsorbed asphalt. Remove excess blotter after the asphalt is absorbed.

411.09 Acceptance. Emulsified asphalt will be evaluated under Subsections 106.02 and 106.03.

Crushed aggregate and blotter will be evaluated under Subsection 106.03.

Construction of the prime coat will be evaluated under Subsections 106.02 and 106.04.

Measurement

411.10 Measure the Section 411 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring prime coat by the square yard (square meter), measure the length along the centerline of the roadway. Include treated widen areas when measuring the width.

When measuring prime coat by the cubic yard (cubic meter) volume, measure in the hauling vehicle. Do not measure water added for dilution. Indicate a breakdown of total emulsion and water added on the load invoices supplied to the CO.

Payment

411.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 411 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 412. — ASPHALT TACK COAT

Description

412.01 This work consists of applying an emulsified asphalt tack coat.

Tack coat emulsified asphalt grade is designated according to AASHTO M 140 or AASHTO M 208.

Material

412.02 Conform to the following Subsection:

Emulsified asphalt	702.02

Construction Requirements

412.03 Equipment. Use equipment conforming to Subsection 407.05.

412.04 Surface Preparation. Clean the existing surface of loose material, dirt, or other deleterious material by approved methods. When the surface is concrete, remove excess joint and crack filler.

412.05 Weather Limitations. Apply asphalt tack only when the following apply:

(a) Surface is dry and unfrozen;

(b) Ambient air temperature is above 35 °F (2 °C) and rising; and

(c) Weather is not foggy or rainy.

412.06 Asphalt Application. When using slow-setting emulsified asphalt, dilute by adding an equal quantity of water to the emulsified asphalt.

Apply the asphalt tack coat according to Subsection 407.09 at a rate of 0.03 to 0.15 gallons per square yard (0.15 to 0.70 liters per square meter).

Apply the asphalt tack coat uniformly and completely by fogging with a hand spray attachment or by another approved method when application with a distributor spray bar is not practical.

Squeegee the excess asphalt from the surface. Allow the tacked surfaces to completely cure before placing the covering course. Place the covering course within 4 hours of placing the asphalt tack coat.

412.07 Acceptance. Emulsified asphalt will be evaluated under Subsections 106.02 and 106.03.

Construction of the tack coat will be evaluated under Subsections 106.02 and 106.04.

Measurement

412.08 Measure the Section 412 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure tack coat including water added for dilution. Indicate a breakdown of total emulsion and water added on the load invoices supplied to the CO for payment.

Payment

412.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 412 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 413. — ASPHALT PAVEMENT MILLING

Description

413.01 This work consists of removing asphalt pavement by a cold milling process.

Construction Requirements

413.02 Equipment.

(a) Milling machine.

(1) Self-propelled;

(2) Sufficient power, traction, and stability to accurately maintain depth of cut;

(3) Capable of removing the pavement thickness to provide profile and cross slope;

(4) Automatic system to control grade elevations by referencing from the existing pavement by means of a ski, matching shoe, or from an independent grade control;

(5) Automatic system to maintain cross slope;

(6) System to effectively limit dust and other particulate matter from escaping removal operations;

(7) Loading system or adequate support equipment to completely recover milled material at removal rate; and

(8) Cutting width equal to at least one-third of the lane width.

(b) Sweeper. See Subsection 409.05(c).

413.03 Milling. Use a longitudinal reference to accurately guide the machine. References may include a curb, edge of pavement, or string attached to the pavement surface. Mill in a longitudinal direction.

Mill the transverse slope to within ¼ inch in 10 feet (6 millimeters in 3 meters) of the required slope. Transition from one transverse slope to another at a uniform rate. Uniformly mill the entire roadway lane width so the cross-section of the new surface forms a straight line.

Transition between different depths of cut at a uniform rate of ½ inch (17 millimeters) of depth per 10 feet (10 meters). At the beginning and end of the milling work, construct a smooth transition to the original surface at this rate. Do not leave an exposed vertical edge perpendicular to the direction of travel. When the pavement remains open to traffic, limit differences in elevation between adjacent lanes according to Subsection 401.15.

Mill the surface to conform to Subsection 403.11.

Use a sweeper immediately behind the milling operations to remove and completely recover loose material. Minimize the escape of dust into the air by misting. Dispose of recovered milled material according to Subsection 211.02(a)(2).

Before opening to traffic, patch defects in milled surface according to the CO.

413.04 Acceptance. Asphalt pavement milling will be evaluated under Subsections 106.02 and 106.04.

Milled surfaces will be evaluated under Subsection 403.11.

Measurement

413.05 Measure the Section 413 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring asphalt pavement milling by square yard (square meter), measure the length horizontally along the centerline of the roadway.

Payment

413.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 413 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 414. — ASPHALT PAVEMENT CRACK SEALING AND FILLING

Description

414.01 This work consists of routing, cleaning, sealing, and filling cracks in asphalt pavement surfaces.

Material

414.02 Conform to the following Section and Subsection:

Asphalt concrete	403
Joint sealants and crack fillers (hot applied)	712.01(a)

Construction Requirements

414.03 Equipment. Furnish equipment with the following capabilities:

(a) Router. A power rotary impact router or vertical spindle router capable of creating a reservoir to the required depth and width without damaging adjacent pavement.

(b) Air lance. A hot compressed air lance capable of providing clean, oil-free compressed air at a volume of 100 cubic feet (2.8 cubic meters) per minute, a pressure of 120 pounds per square inch (830 kilopascals), and a temperature of 2000 °F (1100 °C).

(c) Application wand. A wand attached to a heated hose attached to a heated material chamber that maintains material temperature within manufacturer's tolerances. Supply proper wand tips for desired application.

(d) Heating kettle. An indirect-heating double boiler capable of constant and effective agitation. Fill the space between the inner and outer shells with oil or other heat transfer medium. Provide an accurate and calibrated thermometer with a range from 200 to 600 °F in 5 °F graduations (90 to 320 °C in 2 °C graduations) located so the material temperature can be safely checked.

(e) Squeegee or screed. A hand-held squeegee or screed of appropriate configuration for filling cracks flush with the surface, underfilling cracks to recess below the surface, or overfilling cracks to an overband shape.

(f) Compressor. A compressor capable of producing oil- and water-free air at a minimum rate of 100 cubic feet (2.8 cubic meters) per minute with a minimum continuous line pressure of 125 pounds per square inch (860 kilopascals).

414.04 Routing. Rout, clean, and seal cracks in a continuous operation. Do not allow traffic to close or damage routed cracks.

Rout ⅛- to ½-inch (3- to 13-millimeter) wide cracks to produce vertical, intact walls and a flat bottom with a reservoir centered over the crack. Make the reservoir two to three times the width of the crack. Rout cracks to a depth of ½ to ¾ inches (13 to 19 millimeters).

414.05 Cleaning. Prevent debris from entering waterways, travel lanes open to public traffic, or areas designated not to be disturbed. Remove dirt, dust, and other deleterious material from the crack walls and cavity using a stream of air or other approved methods. Blow or brush dry material off the pavement surface.

414.06 Sealing and Filling. Dry the crack surfaces with the hot air lance before sealing or filling. Do not seal or fill cracks when the pavement surface temperature is below 35 °F (2 °C) and weather conditions are rainy or foggy.

(a) Sealing (routed cracks or cracks averaging ¼ to 1 inch (6 to 25 millimeters) wide). Submit a copy of and adhere to the manufacturer's recommendations for heating and applying the hot applied crack material. Heat the material to pouring temperature in a heating kettle and continuously agitate the material.

Discard sealant when:

(1) Heated above the safe heating temperature recommended by the manufacturer;

(2) Held at pouring temperature for more than 12 hours;

(3) Reheated more than once; or

(4) Not consistent or uniform in appearance.

Warm and dry the crack surfaces using a hot-compressed air lance if the pavement temperature is lower than 50 °F (10 °C) or moisture is present. Keep the lance moving to prevent burning the pavement surface. Place and finish the material within 5 minutes after heating the pavement surface with the lance.

Use an application wand to place material in each crack from the bottom up. Insulate the wand to maintain pouring temperature while placing material. Return the wand to the heating kettle immediately after sealing each crack. Use a squeegee or screed to strike off the material.

(b) Filling (cracks averaging more than 1 inch (25 millimeters) wide). Fill each crack with an asphalt mix according to Section 403. Use a squeegee, screed, or other suitable equipment to force the mix into the crack. Fill each crack flush with the pavement surface and compact the asphalt mixture.

Do not allow traffic on sealed or filled cracks until the sealant or filler has cured or is treated with debonding material recommended by the manufacturer and approved by the CO.

414.07 Resealing Cracks. Reseal cracks exhibiting adhesion failure, damage, incomplete filling, foreign objects in the sealant, or otherwise rejected by the CO.

414.08 Acceptance. Material for asphalt pavement crack sealing or filling will be evaluated under Subsections 106.02 and 106.03.

Asphalt pavement crack sealing and filling will be evaluated under Subsections 106.02 and 106.04.

Measurement

414.09 Measure the Section 414 pay items listed in the bid schedule according to Subsection 109.02.

Payment

414.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 414 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 415. — PAVING GEOTEXTILES

Description

415.01 This work consists of installing paving geotextile and asphalt binder between pavement layers to form a waterproofing and stress-relieving membrane within the pavement structure.

Material

415.02 Conform to the following Subsections:

Asphalt binder	702.01
Blotter	703.12
Paving geotextile	714.01(b)

Construction Requirements

415.03 Submittals. Submit the following for approval at least 10 days before installing the paving geotextile:

(a) A production certification for the geotextile according to Subsection 106.03(a). Include the name of the manufacturer, product name, and style number;

(b) A 18- by 18-inch (460- by 460-millimeter) sample from beyond the first outer wrap of the roll. Label the sample with the lot and batch number, date of sampling, project number, item number, manufacturer, and product name;

(c) The manufacturer's recommended asphalt binder application rate based on field conditions and geotextile asphalt retention properties; and

(d) A plan of operations for installing the geotextile.

415.04 General. Identify, store, and handle geotextile according to ASTM D4873 and the manufacturer's recommendations. Limit exposure to ultraviolet radiation to less than 2 days.

415.05 Surface Preparation. Seal cracks according to Section 414. Clean the existing surface of loose material, dirt, or other deleterious material by approved methods.

415.06 Weather Limitations. Apply asphalt binder and paving geotextile only when the following apply:

(a) Surface is dry and unfrozen; and

(b) Surface temperature is at least 55 °F (13 °C) and rising.

415.07 Asphalt Binder Application. Apply asphalt binder to the pavement surface according to Subsection 407.09 at 290 to 325 °F (140 to 165 °C).

Spray the asphalt binder 6 inches (150 millimeters) wider than the paving geotextile. Do not apply the asphalt binder further than the temporary traffic control zone for this work.

Use the same asphalt binder grade as required in the approved job-mix formula.

415.08 Paving Geotextile Placement. Before the asphalt binder cools and loses tackiness, place the paving geotextile smoothly and with minimal wrinkling onto the binder. Use equipment especially designed to hold the roll and lay down the paving geotextile. Provide uniform tension and broom the geotextile smooth during placement. Slit, lay flat, and tack wrinkles or folds higher than 1 inch (25 millimeters). Cut to remove folds that result in three or more layers of geotextile. Broom and roll the paving geotextile to maximize fabric contact with the pavement surface.

Overlap the geotextile 6 inches (150 millimeters) at longitudinal joints to ensure full closure. Do not overlap transverse joints. Butt adjacent geotextile ends together at transverse joints. Apply additional asphalt binder to paving geotextile overlaps to ensure proper bonding of the double fabric layer.

If asphalt binder bleeds through the fabric, treat the affected areas with blotter.

Broom the excess blotter from the geotextile surface before placing the overlay. Do not turn equipment on the geotextile. Repair damaged fabric before placing overlay.

Limit the lay-down temperature of the asphalt concrete overlay to a maximum of 300 °F (150 °C).

415.09 Acceptance. Asphalt binder will be evaluated under Subsections 106.03 and 106.04.

Material for paving geotextiles will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each shipment of geotextile.

Installation of the paving geotextile will be evaluated under Subsections 106.02 and 106.04.

Blotter will be evaluated under Section 411.

Sealing cracks will be evaluated under Section 414.

Measurement

415.10 Measure the Section 415 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure blotter under Section 411.

Payment

415.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 415 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 416. — RESERVED

Section 417. — RESERVED

Section 418. — ASPHALT CONCRETE PAVEMENT PATCHING

Description

418.01 This work consists of repairing distressed areas of asphalt concrete pavement by removing and patching the pavement and underlying material as required.

Separation and stabilization geotextile is designated according to Table 714-1.

Material

418.02 Conform to the following Sections and Subsections:

Asphalt concrete	403
Asphalt tack coat	412
Crushed aggregate	703.06
Separation and stabilization geotextile and geotextile filter	714.01(a)
Stabilization geogrid	714.03

Construction Requirements

418.03 Asphalt Pavement, Base, and Subgrade Full Depth Patch, Type 1 (FDP-1).

(a) Patch areas. Extend the repair area 12 inches (300 millimeters) beyond the distressed area. If patch limits are within 24 inches (600 millimeters) of the pavement edge, extend the patch limit to the pavement edge. Make the minimum transverse dimension of the patch half of the travel lane width and the minimum longitudinal dimension of the patch 36 inches (900 millimeters).

(b) Pavement removal. Mill completely through the pavement or saw cut and remove the pavement. When saw cutting, cut through the existing pavement and around the perimeter of the patch area. Make saw cuts perpendicular to the roadway surface and at right angles to each other. Remove the pavement, base and subgrade to the depth shown in the plans.

(c) Patching. When required, place geogrid or geotextile according to Section 207. Place and compact crushed aggregate base according to Subsections 302.04 and 302.05. Asphalt millings may be used for crushed aggregate base material. Apply a tack coat to the edges of the patch area according to Section 412. Place and compact asphalt concrete pavement to ensure the patched surface matches the same grade as the adjacent surface.

418.04 Asphalt Pavement Full Depth Patch, Type 2 (FDP-2).

(a) Patch areas. Extend the repair area 12 inches (300 millimeters) beyond the distressed area. If patch limits are within 24 inches (600 millimeters) of the pavement edge, extend the patch limit to the pavement edge. Make the minimum length and width of the patch 36 inches (900 millimeters).

(b) Pavement removal. See Subsection 418.03(b), except remove the pavement to expose subbase or subgrade as shown in the plans.

(c) Patching. Apply a tack coat to the edges of the patch area according to Section 412. Place and compact asphalt concrete pavement so the patched surface matches the same grade as the adjacent surface.

418.05 Asphalt Pavement Partial Depth Patch, Type 3.

(a) Patch areas. Patch areas will be designated by the CO.

(b) Pavement removal. Clean the patch area by sweeping or other acceptable methods.

(c) Patching. Apply a tack coat to asphalt concrete surfaces within the patch area according to Section 412. Place the asphalt material either by hand, with a blade, or other approved method. Compact the asphalt concrete pavement patch to match the grade of the adjacent surface.

418.06 Disposing of Waste. Dispose of debris and unsuitable and excess material according to Subsection 203.05(a) and (d).

418.07 Acceptance. Construction of asphalt concrete pavement patching will be evaluated under Subsections 106.02 and 106.04.

Separation and stabilization geotextiles and geogrid will be evaluated under Subsections 106.02 and 106.03.

Asphalt concrete will be evaluated under Section 403.

Crushed aggregate will be evaluated under Section 302.

Asphalt tack coat will be evaluated under Section 412.

Measurement

418.08 Measure the Section 418 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure asphalt tack coat.

Payment

418.09 The accepted quantities will be paid at the contract unit price per unit of measurement for the Section 418 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 500
RIGID PAVEMENTS

Section 501. — MINOR CONCRETE PAVEMENT

Description

501.01 This work consists of constructing minor concrete pavement on a prepared surface.

Material

501.02 Conform to the following Section:

Minor concrete	601

Construction Requirements

501.03 Composition (Concrete Mix Design). See Subsection 601.03, except conform to Table 501-1.

Table 501-1
Composition of Concrete

Maximum Water/ Cementitious Material Ratio	Slump (maximum), AASHTO T 119	Air Content (minimum)	Coarse Aggregate Size Number AASHTO M 43(1)	28-Day Compressive Strength (minimum), AASHTO T 22
0.45	4 inches (100 millimeters) (fixed form)	5.0%	57 & 67	4000 psi (28 MPa)

(1) Meet the processing requirements of AASHTO M 43, *Table 1 – Standard Sizes of Processed Aggregate*.

501.04 Equipment. Conform to the following:

(a) Forms. Furnish straight, steel forms. For curved edges with radii less than 150 feet (45 meters), furnish flexible or curved forms. Provide forms conforming to the following:

(1) Height equal to the pavement thickness at the edge;

(2) 10-foot (3-meter) minimum length;

(3) Stabilizing devices to secure form to the prepared surface and to withstand paving operations and pressure of concrete with no visible movement or settlement;

(4) Joint locks to join form lengths tightly together; and

(5) Clean and free of hardened concrete, dirt, distortion, and rust.

(b) Paving and finishing.

(1) Fixed form construction. Furnish equipment conforming to either of the following:

(a) Mechanical, self-propelled, finishing machines capable of consolidating and finishing the concrete with minimal hand finishing. Coordinate the number of driving wheels, power of the motor, and the machine's mass to prevent slippage. Do not use machines that displace the fixed forms; or

(b) Manual finishing machines or roller screeds capable of consolidating and finishing the concrete.

(2) Vibrators. Furnish internal immersed tube or multiple spud type vibrators for paving more than 8 inches (200 millimeters) thick. Surface pan type vibrators are acceptable for full-width concrete consolidation of slabs 8 inches (200 millimeters) or less in thickness. Operate the vibrators at frequencies within 5,000 to 8,000 vibrations per minute. Attach vibrators to the spreader or finishing machine or mount on a separate carriage that precedes the finishing machine. For construction of irregular areas, use hand-held vibrators operated at a frequency recommended by the manufacturer.

(c) Concrete saws. Furnish concrete saws that are capable of sawing new concrete for crack control to the required depth and alignment. Equip saws with blade guards and devices to control alignment and depth.

(d) Joint sealing. Furnish sealing equipment according to the sealant manufacturer’s recommendations.

501.05 Production Start-Up Procedures. Conduct a pre-minor concrete pavement preparatory phase meeting according to Subsection 153.04(a).

501.06 Surface Preparation and Setting Forms. Prepare the roadbed surface according to Section 301. Maintain the surface to avoid the development of loose and uncompacted material.

Set and align forms to the plan dimensions and elevations. Securely brace forms so they will not bulge or warp during concrete placement. Apply form release agent or form oil to the inside form faces. Align forms to the dimensions and elevations in the plans and assure there is no bulging or warping.

Check and correct roadbed surface deformations and rutting exceeding ½ inch (13 millimeters) and uniformly dampen the surface before placing concrete.

501.07 Placing Concrete. At least 14 days before the start of concrete placement operations, arrange a pre-paving conference. Coordinate attendance with the CO and applicable subcontractors. Submit and be prepared to discuss the following:

(a) Proposed pour sequence and placement schedule;

(b) Approved concrete mix design;

(c) Contractor quality control plan;

(d) Equipment, batching, mixing, placing, and curing requirements;

(e) Subsections 106.03 and 106.04;

(f) Jointing plan, joint forming or sawing operations, rain protection plan, hot and cold weather paving plan, and opening to traffic requirements; and

(g) Traffic control plan.

Conform to Subsections 552.04 through 552.08 and 552.10 for weather limitations, handling, storing, batching, and mixing material and delivering concrete.

Deposit concrete between the forms to a uniform height. Consolidate concrete to remove voids and air pockets. Do not move concrete horizontally with vibrators.

Strike off and place concrete with a form-riding paving machine or manual fixed form paving equipment. In irregular areas where a paving machine is impractical, place concrete using templates, screeds, or other methods approved by the CO.

Carry a slight excess of concrete in front of the leading edge of the template or screed. After strikeoff and before bleed water appears on the surface, float to the required grade and cross-section. Finish the concrete pavement to minus ¼ inch (6 millimeters) or plus ⅜ inch (10 millimeters) of the thickness required.

When concrete is placed adjoining a previously-constructed lane of pavement, do not operate mechanical equipment on the existing lane until the lane has attained:

- A minimum flexural strength of 450 pounds per square inch (3.1 megapascals) according to AASHTO T 23 and AASHTO T 97; or
- A compressive strength of 3,000 pounds per square inch (21 megapascals) according to AASHTO T 22 and AASHTO T 23.

When required, place reinforcing steel according to Section 554. If placing rebar before placing concrete, position the rebar on acceptable supports. If placing rebar after placing concrete, mechanically insert the rebar to the required depth. Reinforcing bars and steel supports are to be epoxy-coated. Keep epoxy-coated reinforcing steel free of damage and distortion. Steel wire fabric and mats are not required to be epoxy-coated.

When rain is threatening during paving operations, stop paving operations and protect the concrete pavement from rain with plastic sheeting or other methods approved by the CO. Remove, replace, or repair pavement damaged by rain or hail as directed by the CO at no cost to the Government.

501.08 Joints. Construct joints at locations and dimensions indicated in the plans. If jointing locations are not indicated in the plans, submit a jointing plan according to Subsection 104.03. Indicate locations of contraction, construction, and isolation joints.

Do not vary longitudinal joints more than ½ inch (13 millimeters) and transverse joints more than ¼ inch (6 millimeters) from true alignment. When curbs or medians are constructed integral with the pavement, construct transverse joints continuous through the curb or median. Clean joints of deleterious material, including concrete slurry, and protect the joints until sealed.

(a) Longitudinal joints. Construct longitudinal construction joints by using steel fixed forms and a keyway along the joint.

Where required, place deformed steel tie bars perpendicular to the longitudinal joints with mechanical equipment or rigidly secured chairs without damaging or disrupting the concrete. Along longitudinal construction joints, tie bars may be bent at right angles against the form of the first lane constructed and straightened into final position before placing concrete in the adjacent lane. Repair or replace broken or damaged tie bars.

Threaded hook bolts may be used instead of tie bars. Fasten hook bolts to the form of the longitudinal construction joint.

Construct joints as follows:

(1) Formed joints. Form joints with an approved nonmetallic or removable device while the concrete is plastic, but set sufficiently to maintain the formed joint. When adjacent lanes are constructed separately, form the sealant reservoir in the lane placed last.

(2) Sawed joints. After placing concrete, saw joints approximately ⅛ inch (3 millimeters) wide as soon as equipment can be supported and before uncontrolled cracking occurs. Do not ravel the joints while sawing. Saw longitudinal joints immediately after sawing transverse joints. Protect the sawed concrete faces from drying during the curing period. Saw sealant reservoirs no sooner than 72 hours after placing the concrete.

If necessary, continue sawing day and night, regardless of weather conditions.

Do not saw a joint if a crack occurs at or near the joint location before sawing. Discontinue sawing when a crack develops ahead of the saw.

Remove and replace newly-placed concrete pavement where uncontrolled cracking occurs. Dowel and tie replacement pavement to adjacent pavement as specified.

(b) Transverse contraction joints. When required, construct contraction joints according to Subsection 501.08(a)(1) or (a)(2).

Where required, place dowel bars through and centered on traverse joints and in the middle of the slab depth. Align and hold dowels parallel to the surface and centerline of the slab by a metal assembly that remains in the pavement and is rigidly secured to the base or subgrade using stakes or nails. Limit deviations from parallel to ¼ inch (6 millimeters) in the length of the dowel bar. Assure proper alignment of joint and dowel bar assemblies.

Coat each dowel bar with an approved bond breaker. Limit bond breaker coating thickness to 15 mils (380 micrometers).

Concrete edges adjacent to the joint may be rounded or beveled to a radius no greater than ¼ inch (6 millimeters) or as approved. Resaw or grind joints having an insufficient opening. Where a joint is larger than required, furnish a larger size joint seal as approved.

(c) Transverse construction joints. Construct transverse construction joints only at locations specified, at the end of each work shift, or when concrete placement is interrupted for more than 30 minutes. If necessary, remove and dispose of the excess concrete to the last preceding joint.

When required, install dowel bars in transverse construction joints according to Subsection 501.08(b).

Use a metal or wooden bulkhead to form the joint, shaped to the pavement cross-section and designed to permit the installation of dowel bars.

(d) Isolation joints. Form isolation joints around manholes, utility boxes, foundations, other fixed objects, or as indicated in the plans. Place a ½-inch (13-millimeter) pre-formed joint filler continuously around or along each structure that extends into or through the pavement before concrete is placed. After the concrete hardens, recess the joint filler about ¾ inch (19 millimeters) to allow a reservoir for sealant.

When required, place steel wire fabric at the location and orientation specified. Use metal or plastic chairs or other methods approved by the CO to support the steel wire fabric.

501.09 Surface Finishing. Protect the surface from rain damage.

After floating, check the surface of the fresh concrete with a 10-foot (3-meter) straightedge. Remove high areas indicated by the straightedge. Lap each successive check with the straightedge 5 feet (1.5 meters) over the previous check path.

Before the concrete has initially set, work the pavement edges on each side of isolation joints, formed joints, transverse and longitudinal construction joints, and emergency construction joints to produce a ¼ inch (6 millimeters) or less continuous radius and a smooth, dense mortar finish. Do not use mortar buildup to round edges.

As soon as excess moisture has disappeared and while the concrete is still plastic enough to make a granular surface possible, texture the surface to produce a skid resistant surface. Use the method specified and conform to the following:

(a) Transverse tine finish. Drag two layers of moistened burlap along the pavement in the direction of paving without tearing or marring the surface. Following the burlap drag, use a tining comb to form grooves in the pavement surface. Space tines randomly ½ to ¾ inches (13 to 19 millimeters) apart. Produce grooves that are $^{1}/_{16}$ to $^{3}/_{16}$ inches (1.6 to 5 millimeters) wide and ⅛ to $^{3}/_{16}$ (3 to 5 millimeters) inches deep. Tine perpendicular to the centerline without tearing the concrete surface or loosening surface aggregate.

(b) Broom finish. Broom the surface with a steel or stiff-bristled fiber broom to produce corrugations between $^{1}/_{16}$ and ⅛ inch (1.6 to 3 millimeters) deep. Broom perpendicular to the centerline from edge to edge with adjacent strokes slightly overlapped. Use the same type and manufacture of broom for all paved surfaces to provide a consistent appearance.

(c) Exposed aggregate finish. Broom the surface. Use stiff brushes approved by the CO. Exercise care to prevent marring of the surface and cracking or chipping of slab edges or joints. If approved by the CO, apply a light spray of retardant to the unfinished surface to facilitate this work.

Broom transversely across the pavement. Pull the loosened semi-stiff mortar off the pavement. Remove the mortar from adjacent pavement. Broom parallel to the centerline. Continue this operation until a sufficient quantity of coarse aggregate is exposed. Other methods of aggregate exposure will be permitted if satisfactory results are demonstrated.

After curing, wash the surface with water and brush to remove laitance and cement from the exposed coarse aggregate.

501.10 Curing. Immediately after finishing and when marring will not occur; cure the surface and exposed sides of concrete for at least 72 hours. Do not leave the concrete exposed for more than 30 minutes during the curing period. Cure using one of the following methods:

(a) Water method. Cure according to Subsection 552.15(b). Cover the entire surface of the pavement and edges of the slab with water saturated mats. Extend the mats at least twice the thickness of the pavement beyond the edges of the slab. Place the mats in complete contact with the surface. Use weights or other approved methods to maintain contact; or

(b) Liquid membrane curing compound method. Cure according to Subsection 552.15(c).

Remove forms when the concrete has hardened sufficiently to resist damage, but no earlier than 12 hours after placing concrete. Protect the sides of the exposed slabs with a curing method equal to that provided for the surface. Prevent erosion of the base course beneath the exposed pavement edges until shoulders are constructed.

501.11 Sealing Joints. Saw cut and seal joints before the pavement is opened to construction or public traffic.

Where sealant reservoirs are required, clean each sealant reservoir of foreign material including membrane curing compound and concrete slurry. Blow dry joints with moisture free compressed air. Do not apply sealing material unless the joint faces are clean and surface dry, and the joint is free of incompressibles.

Use preformed joint seals, silicone sealant, or hot-poured sealant for isolation joints. Use silicone or hot-poured sealants for longitudinal and transverse contraction joints.

(a) Silicone or hot-poured sealants. Install backer rod with a steel wheel to the depth required. Do not stretch or twist the backer rod during installation. Limit the length of backer rod installed to that which can be sealed during the same workday.

Place joint sealing material when the air temperature is over 40 °F (4 °C) or as specified by the manufacturer. Remove excess or spilled material and clean the pavement surface. Do not use sand or similar material to cover the seal. For sealants that are not self-leveling, tool the surface of the sealant to the dimensions required in the plans.

(b) Preformed joint seals. Furnish the seal in one piece in the size specified for the joint opening. Install seals with a lubricant adhesive covering both sides of the joint. Compress the seal to between 20 and 50 percent of its nominal width or as specified by the manufacturer. Install the top of the seal about ¼ inch (6 millimeters) below the pavement surface.

Remove and replace seals that are damaged, twisted, improperly positioned, or stretched more than 3 percent.

501.12 Pavement Straightedge Measurement. Measure the pavement surface after the concrete has cured. Use a 10-foot (3-meter) metal straightedge to measure at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge in excess of ¼ inches (6 millimeters), measured between two contacts of the straightedge, or deviations in excess of ¼ inches (6 millimeters) measured at the end of the straightedge.

Correct defective areas by diamond grinding, slab removal, or other methods approved by the CO.

501.13 Opening to Traffic. Do not allow traffic on new concrete pavement earlier than 14 days after concrete placement unless concrete tests indicate one of the following conditions is obtained:

(a) Flexural strength of 550 pounds per square inch (4 megapascals) according to AASHTO T 97; or

(b) Compressive strength of 4000 pounds per square inch (28 megapascals) according to AASHTO T 22.

Do not allow traffic on the pavement when joint sealant is tacky and traffic debris would imbed into the sealant.

501.14 Acceptance. See Table 501-2 for sampling, testing, and acceptance requirements.

Material for minor concrete pavement will be evaluated under Section 601.

The concrete mixture's slump, air content, density, temperature, and compressive strength will be evaluated under Subsections 106.02 and 106.04.

Construction of concrete pavement will be evaluated under Subsections 106.02 and 106.04.

Pavement straight edge will be evaluated under Subsection 106.04.

Measurement

501.15 Measure the Section 501 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring concrete pavement by the square yard (square meter), measure the length horizontally along the centerline of the roadway. Measure the width including allowable curve widening.

Payment

501.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 501 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 501-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (703.01 & 703.02)	Measured and tested for conformance (106.04 & 105)	Quality	–	AASHTO M 80 M 6 M 43	1 per material type	Source of material	Yes	14 days before paving	–
Mix Design									
Concrete composition (501.03)	Measured and tested for conformance (106.04 & 105)	All	–	Subsection 501.03	1 per mix design	Source of material	Yes	14 days before paving	–

Table 501-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Concrete	Measured and tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load [2]	Point of discharge [3]	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or T 196	"	"	"	"	–
		Slump	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	Field measured	"	"	"	"	–
		Compressive strength [1][4]	–	AASHTO T 23 & T 22	1 set per 200 yd^2 (170 m^2), but not less than 1 set per day	"	See Note (4)	"	Deliver verification cylinders to the CO or designated location in time for 28-day break
Aggregate (coarse & fine)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	1 per day min	Bin discharge, conveyor belt, or stockpile	No	Before batching	–
		Moisture	–	AASHTO T 255	"	"	"	"	–
Concrete	"	Surface tolerance	–	Straightedge measurements Subsection 501.07	Subsection 501.07	Concrete surface, after floating	"	While concrete is still workable	–

Table 501-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Roadway									
Concrete pavement	Measured and tested for conformance (106.04)	Surface tolerance	−	Straightedge measurements Subsection 501.12	Successively, after concrete has hardened	Finished pavement surface	No	24 hours	−
		Pavement thickness	−	AASHTO T 148	"	"	"	"	When directed by the CO

(1) A single compressive strength test result is the average result from two 6 by 12 inch (150 by 300 millimeter) or three 4 by 8 inch (100 by 200 millimeter) cylinders cast from the same load and tested at 28 days.

(2) This frequency may be reduced by the CO if produced material proves to be consistent.

(3) Sample according to AASHTO R 60, except composite samples are not required.

(4) Make at least four 6 by 12 inch (150 by 300 millimeter) or six 4 by 8 inch (100 by 200 millimeter) compressive strength test cylinders and carefully transport the cylinders to the project curing facility. Two or three cylinders will be used for 28-day compressive strength tests. The remaining cylinders will be used by the CO for verification testing or other designated purposes.

Section 502. — CONCRETE PAVEMENT RESTORATION

Description

502.01 This work consists of concrete pavement restoration. Concrete pavement restoration includes full depth patching, partial-depth patching, pavement jacking, subsealing, surface grinding, crack and joint repair, and cleaning.

Material

502.02 Conform to the following Section and Subsections:

Epoxy resin adhesive	725.18
Latex modifier	711.04
Minor concrete pavement	501
Nonshrink grout	725.13(b)
Polymer concrete and mortar	725.14
Reinforcing steel	709.01

502.03 Composition of Mix (Concrete Mix Design). Design the concrete mix according to Subsection 501.03.

502.04 Equipment. Furnish equipment conforming to the following:

(a) Waterblaster. Furnish a high-pressure water jet machine with at least 2500 pounds per square inch (17.5 megapascals) pressure and is capable of removing residual sealant, oil, or other foreign material in joints.

(b) Air compressors. Furnish air compressors with a minimum nozzle pressure of 100 pounds per square inch (700 kilopascals) and capable of dislodging loose debris and drying joints and cracks.

(c) Grout plant. Furnish a grout plant which consists of a positive displacement cement injection pump and a high-speed colloidal mill. Operate colloidal mill at speeds necessary to make a homogeneous mixture.

Furnish an injection pump having a pressure capability of 275±25 pounds per square inch (1900±170 kilopascals) when pumping a grout slurry mixed to a 12-second flow cone time and that continuously pumps at a minimum rate of 1.5 gallons (6.0 liters) per minute. The system may be modified by adding a recirculating hose and valve at the discharge end of the pump.

Produce grout through a meter or scale capable of measuring the total day's consumption. Furnish hoses and fittings to provide a positive seal during grout injection.

(d) Drills. Furnish drills that meet the following:

(1) Drills for pavement jacking. Furnish rock drills capable of drilling straight, minimum 1½-inch (38-millimeter) diameter holes through the concrete slab, steel reinforcement, and base material. Furnish rock drills weighing less than 60 pounds (27 kilograms) that are capable of drilling with a downward pressure of less than 200 pounds (90 kilograms). Furnish an auger to open clogged holes and existing pavement jacking holes.

(2) Drills for dowels and tie bars. Furnish drills capable of drilling specified hole diameters for dowel bars or reinforcing steel tie bars. Drills for dowel bars must be capable of drilling holes that meet the vertical and horizontal tolerance of ±¼ inch (±6 millimeters) along the centerline of the dowel with respect to a horizontal line that is perpendicular to the plane established by the joint.

(e) Surface diamond grinder. Furnish power driven, self-propelled grinding equipment, specifically designed to smooth and texture concrete pavement with diamond blades. Furnish equipment that:

(1) Cuts or planes at least 36 inches (900 millimeters) in width;

(2) Does not encroach on traffic movement outside of the work area; and

(3) Grinds the surface without spalling.

(f) Hydroblaster. Provide hydroblasting equipment conforming to Subsection 560.05.

(g) Cold planing (milling) machine. Provide a milling machine, with a micromilling head that does not exceed the bearing capacity of the concrete pavement and that conforms to Subsection 413.02(a).

(h) Slab stabilization testing. Furnish the following testing equipment:

(1) A 2-axle truck with dual rear wheels. Load the rear axle to 18 kips (80 kilonewtons) evenly distributed between the 2 wheel paths;

(2) Static load measuring gauges consisting of 4 gauges on 2 gauge mounts, 2 gauges per mount, capable of detecting slab movement under load; and

(3) A modified Benkelman beam or similar approved device.

502.05 Partial-Depth Patching (less than 4 inches (100 millimeters) in depth). This work consists of patching spalls, potholes, corner breaks, or other surface distresses in concrete pavement.

(a) Patch material. Use a polymer concrete for patches less than or equal to 1½ inches (38 millimeters) deep. Use hydraulic cement concrete designed and approved according to Subsection 501.03 for patches greater than 1½ inches (38 millimeters) deep.

(b) Patch area preparation. Extend the limits of repair at least 4 inches (100 millimeters) outside the deteriorated area. Saw vertically along the perimeter of the patch area, parallel to the existing joint, and to a minimum depth of 1½ inches (38 millimeters). Near vertical edges from milling or grinding machines are acceptable. Repair saw overcuts and nicks to adjacent pavement outside the perimeter of the repair area with noncorrosive, non-shrink grout.

Break out concrete within the patch area to a minimum depth of 1½ inches (38 millimeters) to expose sound concrete. Sandblast exposed concrete faces clean of loose particles, oil, dust, traces of asphalt concrete, and other contaminants before patching.

Remove non-concrete shoulders adjacent to the patch longitudinally to the depth of the patch and to a maximum width of 12 inches (300 millimeters) to facilitate placing form work.

Dispose of the concrete according to Subsection 203.05.

(c) Placing concrete. Remove sandblasting residue immediately before placing the epoxy resin adhesive. Apply an epoxy resin adhesive according to the manufacturer's recommendations. Delay concrete placement until the epoxy becomes tacky.

Place and consolidate the concrete to eliminate voids at the interface of the patch and existing concrete. Place and consolidate hydraulic cement concrete according to Subsection 501.07. Place and consolidate polymer concrete according to climate conditions and methods recommended by the manufacturer.

(d) Joints. If a repair area abuts a working joint, repair the joint similar to the existing joint to maintain a working joint. Form a new joint to the same width as the existing joint. Use compressible joint filler material as inserts to prevent intrusion of the repair material into the joint. Seal the joint according to Subsection 502.08.

(e) Finishing and coloring concrete. Finish patches according to Subsection 501.09 to match the plane and texture of the contiguous pavement. Cure hydraulic cement concrete according to Subsection 501.10. Cure polymer concrete as recommended by the manufacturer.

When colored concrete is required, begin concrete pavement restoration work after colored test panels submitted according to Subsection 501.03 are approved.

Restore and compact shoulders with material similar to the existing shoulder.

502.06 Full Depth Patching (welded wire reinforced, jointed, plain doweled, or plain concrete pavement). This work consists of removing existing concrete pavement the full depth and replacing with new concrete. Begin pavement patch work after the concrete mix design has been approved according to Subsection 501.03.

(a) Concrete removal. Saw cut slabs full depth leaving vertical edges at the limits of the patch. Prevent adjacent concrete slabs from being damaged.

Remove the concrete by lifting the slab in one or more pieces without disturbing the underlying surface. Clean out the area with hand tools. Dispose of the concrete according to Subsection 203.05. When required, excavate the underlying material to a maximum depth of 12 inches (300 millimeters) and replace with aggregate base according to Section 302. Prevent adjacent concrete slabs from being undermined.

Remove and replace adjacent slabs damaged by concrete removal. Repair spalls using partial-depth patching methods according to Subsection 502.05.

Repair saw overcuts of repair areas and nicks to adjacent pavement outside the perimeter of the repair area with nonshrink grout.

(b) Joints. Construct joints according to Subsection 501.08 and the following:

Install dowels, tie bars, or both into existing concrete pavement slabs as shown in the plans. Drill dowel or tie bar holes into the face of the existing concrete at the required diameter, length, and spacing using a drill according to Subsection 502.04(d)(2). Clean and dry the holes before installing the dowels or tie bars. Use an epoxy resin to permanently anchor the dowel or tie bar into the existing concrete. Place the epoxy resin starting from the back of the hole and use a sufficient quantity to insure the epoxy material will be forced up and around the dowel or tie bar after insertion. Place a thin, donut-shaped grout retention disk around the dowel or tie bar and up against the face of the existing concrete to prevent epoxy resin material from flowing out of the hole.

Seal joints according to Subsection 501.11.

(c) Welded wire reinforcement. When required, provide 4- by 4-inch (100- by 100-millimeter), W6 by W6 (M15 by M15) steel welded wire reinforcement for crack control. Support welded wire fabric on chairs or bolsters.

(d) Concrete placement. Compact base and subgrade material within the patch area according to Subsection 302.05. Construct side forms to overlap the ends of the existing slab. Securely fasten side forms so they do not move when concrete is placed. To accommodate forms for the patch, excavate the adjacent shoulders a maximum width of 12 inches (300 millimeters). Place concrete according to Subsection 501.07.

Cast each patch in one continuous full-depth operation. After removal of the forms, backfill, compact, and return the excavated shoulder area to its previous condition.

(e) Finishing and coloring concrete. Finish patches according to Subsection 502.05(e).

502.07 Resealing Joints and Crack Repair. This work consists of repairing or resealing joints and cracks in existing concrete pavement.

(a) Preparation of joints and cracks. Limit the length of joints and cracks prepared to that which can be resealed within the same shift. Do not damage joints or previously repaired patches.

Remove existing sealant with a waterblaster, router, concrete saw, or other method approved by the CO.

Remove old sealant from the crack faces to expose new, clean concrete. When the crack widths vary and the crack faces are raveling and irregular, cut a crack reservoir to a depth of ¾ inch (19 millimeters).

Thoroughly clean the joint or crack of foreign material by sandblasting, waterblasting, or with a mechanical wire brush. Repeat the process until a new, clean concrete face is exposed. Dry the joint with compressed air.

Use sawing if other methods do not properly clean the joint. Limit sawing to exposing clean, new, concrete faces in the joint with a maximum allowable cut of ⅛ inch (3 millimeters) on each face of the joint.

(b) Backer rod. Install the backer rod to the required depth after the joints and cracks are clean and dry. Do not stretch or twist the backer rod during installation. Limit the length of backer rod installed to that which can be sealed during the same shift.

(c) Sealant application. Seal joints and cracks immediately after placing the backer rod. Apply sealant at air and surface temperatures recommended by the sealant manufacturer. Comply with installation recommendations provided by the sealant manufacturer. If the joint or crack becomes contaminated or damp, remove the backer rod, clean and dry the joint or crack, and reinstall a new backer rod before placing the sealant. For a non-self-leveling joint sealant, tool the sealant immediately after application to provide firm contact with the joint faces and to form the required recess below the slab surface.

502.08 Pavement Jacking. This work consists of raising and supporting the concrete pavement to the specified grade tolerances by drilling and injecting non-shrink hydraulic cement grout.

(a) Drilling holes. Determine a pattern for grout injection holes and submit for approval. Drill vertical holes less than 2 inches (50 millimeters) in diameter.

(b) Jacking. Establish string lines from the pavement high points to monitor slab movement. Lower an expanding rubber packer or hose into the holes. Provide a positive seal and connected to the discharge hose on the grout plant. Do not allow the discharge end of the packer or hose to extend below the bottom of the concrete pavement.

Allow pumping to raise the pavement to within ⅛ inch (3 millimeters) of the string line grade when jacking continuously-reinforced concrete pavement. Allow pumping to raise the pavement to within ¼ inch (6 millimeters) of the transverse and longitudinal grades when jacking jointed pavement and bridge approach slabs.

Continuous jacking pressures to 200 pounds per square inch (1.4 megapascals) are permitted. Use pressures to 300 pounds per square inch (2.1 megapascals) only for short periods of 30 seconds or less. If the pavement is bonded to the subbase, brief pressure rises of 10 seconds or less to 600 pounds per square inch (4.1 megapascals) may be allowed. Stop pumping if grout extrudes through cracks, joints, or shoulders. Discontinue pumping if back pressure in the hose exceeds 600 pounds per square inch (4.1 megapascals).

(c) Overjacking. Grind pavement raised above the specified tolerances to grade. Remove and replace the pavement according to Subsection 502.06 if the overjacking is greater than 1 inch (25 millimeters).

(d) Cracks. Radial cracks from the grout injection holes will be considered caused by improper injection technique. Remove and replace the slab or a portion of the slab with more than 10 feet (3 meters) of new cracks according to Subsection 502.06. For slabs with less than 10 feet (3 meters) of new cracks, seal cracks according to Subsection 502.07.

(e) Hole patching. After completing the jacking and the hole plugs are removed, fill drill holes flush with the pavement surface with a nonshrink grout or epoxy mortar.

502.09 Undersealing and Slab Stabilization. This work consists of pumping a nonshrink grout mixture through holes drilled in the pavement into voids underneath the slabs to stabilize and underseal concrete pavement.

(a) Preliminary testing. Perform testing at night or when there is no evidence of slab lock-up due to thermal expansion. Testing may be allowed to continue if the slabs are not interlocked or under compression. Furnish testing equipment as provided in Subsection 502.04(h). Test each designated slab using a static method as follows:

(1) Position one set of gauges with one gauge referenced to the corner of each slab on both sides of the joint near the pavement edge;

(2) Set the gauges to zero with no load on the slab on either side of the joint;

(3) Move the test truck into position and stop with the center of the test axle 12 inches (300 millimeters) behind the joint and the outside test wheel 12 inches (300 millimeters) from the pavement edge. Read the back gauge;

(4) Move the test truck across the joint to a similar position 12 inches (300 millimeters) forward from the joint and stop. Read the forward gauge; and

(5) Repeat for each joint to be tested. Underseal slabs with a deflection of more than $^{1}/_{32}$ inch (0.08 millimeters).

(b) Drilling holes. Drill holes using the required hole pattern. An altered hole pattern may be approved based on field conditions. Drill vertical holes less than 2 inches (50 millimeters) in diameter to provide a positive seal for the pumping nozzle. For the first undersealing, drill holes to a depth that penetrates into unbound base or subgrade. Avoid penetrating the subgrade by more than 3 inches (75 millimeters).

(c) Cleaning holes. After the holes are drilled and before pumping the underseal grout, clean the hole with compressed air to remove debris and provide a passage for the grout.

(d) Pumping underseal grout. Pump nonshrink grout in each hole. Seal the nozzle of the discharge hose in the hole to maintain the nonshrink grout pressure underneath the slab. Do not allow the nozzle end to extend below the bottom of the concrete. Monitor slab lift according to Subsection 502.08. Limit upward movement of the pavement to ⅛ inch (3 millimeters).

Continue pumping into a hole until grout flows out other holes, joints, or cracks, or until the slab begins to lift. Stop grouting if there is lift in the slab or the adjacent shoulder.

During stabilization operations, limit continuous pumping pressures to 125 pounds per square inch (0.9 megapascals). Allow a short pressure surge of up to 300 pounds per square inch (2 megapascals) when starting to pump grout into the hole to ensure grout penetrates the void structure. Do not plug other holes while grouting.

Grind pavement raised more than the ⅛ inch (3 millimeters).

(e) Cracks. If cracks develop, complete the required repairs according to Subsection 502.07.

(f) Hole patching. See Subsection 502.08(e).

(g) Stability testing. Test for stability 24 hours after designated slabs have been undersealed according to Subsection 502.09 (a). Complete a second underseal operation on slabs that continues to show excess movement. Submit the number, depth and location of holes for the second undersealing for approval. The CO may accept or direct replacement of slabs that continues to show movement in excess of that specified after undersealing twice. Remove and replace designated slabs according to Subsection 502.06.

502.10 Surface Diamond Grinding. This work consists of grinding existing concrete pavement to eliminate joint or crack faults and providing positive lateral drainage. Uniformly transition auxiliary or ramp lane grinding from the mainline edge to provide positive drainage and an acceptable riding surface. Provide a grinding unit conforming to the requirements of Subsection 502.04(e).

Produce a pavement surface that is true to grade, smooth, and consisting of a longitudinal corduroy-type texture. Produce grooves between 0.08 and 0.15 inches (2 to 4 millimeters) wide. Produce a surface area between the grooves between 0.065 and 0.125 inches (1.7 to 3.5 millimeters) wide. Produce peak ridges approximately $^{1}/_{16}$ inch (1.6 millimeters) higher than the grooves. Adjust blade spacing to achieve the specified texture. Establish a positive and immediate means for removal of grinding residue. Remove and dispose of solid residue from the pavement surfaces before it is blown by traffic action or wind. Do not allow residue to flow into gutters or drainage facilities.

Test the ground pavement surfaces for pavement roughness according to Subsection 501.12. Limit misalignment of surface planes on adjacent sides of the joints or cracks and between each grinding pass to less than $^{1}/_{16}$ inch (1.6 millimeters). Produce a transverse slope of the pavement with no depressions or slope misalignment greater than ¼ inch in 10 feet (6 millimeters in 3 meters) tested perpendicular to the centerline. Straightedge requirements do not apply across longitudinal joints or outside of ground areas.

502.11 Concrete Cleaning. This work consists of cleaning the existing concrete pavement surface with a high pressure washing device approved by the CO. Remove dust, dirt, oil, and other foreign material (including the existing crack sealant material) without causing damage to the surface or exposing coarse aggregate.

Vacuum the concrete surface to remove and collect water and debris after the pavement cleaning. Dispose of the water and debris at a site approved by the CO.

502.12 Opening to Traffic. Do not allow traffic on restored pavement until the concrete has a compressive strength of 4000 pounds per square inch (28 megapascals) when tested according to AASHTO T 22 or until the grout used for jacking or undersealing the pavement has attained 600 pounds per square inch (4 megapascals) when tested with a 0.25 square inch (64 square millimeters) probe according to AASHTO T 197. As an alternative method of determining the compressive strength of the restored pavement; in situ compressive strength can be measured by developing a strength-maturity relationship of the approved concrete mixture according to AASHTO T 325. Submit the strength-maturity relationship for approval at least 14 days before production. Provide a concrete maturity meter during the test placement and production that meets the following:

(a) Conforms to AASHTO T 325;

(b) Rugged, waterproof, and can withstand the construction environment;

(c) Able to operate without an external power source for at least 14 days;

(d) Able to collect and store temperature and maturity data for at least 14 days; and

(e) Able to determine equivalent maturity hours according to the Arrhenius function.

Do not allow traffic on sealed joints when the sealant is tacky and traffic debris embeds into the sealant.

502.13 Acceptance. See Table 502-1 for sampling, testing, and acceptance requirements.

Material for concrete pavement restoration will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each shipment of hydraulic cement.

The concrete mixture's slump, air content, density, temperature, and compressive strength will be evaluated under Subsections 106.02 and 106.04.

Grout will be evaluated under Subsections 106.02 and 106.03.

Construction (including batching, placing, finishing, and curing) of the concrete will be evaluated under Subsections 106.02 and 106.04.

Concrete pavement restoration work (including partial-depth patching, pavement jacking, subsealing, surface grinding, crack and joint repair, cleaning, and breaking and seating will be evaluated under Subsections 106.02 and 106.04.

Measurement

502.14 Measure the Section 502 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring grout for pavement jacking and undersealing by the cubic foot (cubic meter), measure by metering.

Measure aggregate base under Section 302.

Payment

502.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 502 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 502-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (703.01 & 703.02)	Measured and tested for conformance (106.04 & 105)	Quality	–	AASHTO M 80, M 6, & M 43	1 per material type	Source of material	Yes	14 days before paving	–
Mix Design									
Concrete composition (501.03)	Measured and tested for conformance (106.04 & 105)	All	–	Subsection 501.03	1 per mix design	Source of material	Yes	14 days before paving	–
Production									
Concrete	Measured and tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load [2]	Point of discharge [3]	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or T 196	"	"	"	"	–
		Slump	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	Field measured	"	"	"	"	–

Table 502-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Concrete	Measured and tested for conformance (106.04)	Compressive strength [(1)(4)]	–	AASHTO T 23 & T 22	1 set per 200 yd^2 (170 m^2), but not less than 1 set per day	Point of discharge [(3)]	See Note (4)	"	Deliver verification cylinders to the CO or designated location with in 28 days
Aggregate (coarse & fine)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	Minimum 1 per day	Bin discharge, conveyor belt, or stockpile	No	Before batching	–
		Moisture	–	AASHTO T 255	"	"	"	"	–
Concrete	"	Surface tolerance	–	Straightedge measurements Subsection 501.12	Subsection 501.08	Concrete surface, after floating	"	While concrete is still workable	–

Table 502-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Concrete pavement	Measured and tested for conformance (106.04)	Surface tolerance	–	Straightedge measurements Subsection 501.12	Successively, after concrete has hardened	Finished pavement surface	No	24 hours	–

(1) A single compressive strength test result is the average result from two 6 by 12 inch (150 by 300 millimeter) or three 4 by 8 inch (100 by 200 millimeter) cylinders cast from the same load and tested at 28 days.

(2) This frequency may be reduced by the CO if produced material proves to be consistent.

(3) Sample according to AASHTO R 60.

(4) Make at least four 6 by 12 inch (150 by 300 millimeter) or six 4 by 8 inch (100 by 200 millimeter)compressive strength test cylinders and carefully transport the cylinders to the project curing facility. Two or three cylinders will be used for 28-day compressive strength tests. The remaining cylinders will be used by the CO for verification testing or other designated purposes.

DIVISION 550
BRIDGE CONSTRUCTION

Section 551. — DRIVEN PILES

Description

551.01 This work consists of furnishing and driving piles. This work also includes furnishing and placing reinforcing steel and concrete in concrete-filled steel shell and concrete-filled pipe piles.

Material

551.02 Conform to the following Sections and Subsections:

Concrete piles	715.03
Grout	725.13
Paint	719
Pile shoes	715.08
Prestressing steel	709.02
Reinforcing steel	709.01
Sheet piles	715.07
Splices	715.09
Steel H-piles	715.06
Steel pipes	715.05
Steel shells	715.04
Structural concrete	552
Treated timber piles	715.02
Untreated timber piles	715.01

Construction Requirements

551.03 Qualifications. Submit the following for approval at least 30 days before driven pile operations begin:

(a) Professional engineer. Name of the engineer and a résumé describing at least 3 years' experience in wave equation analyses to perform the wave equation analysis.

(b) Pile specialty consultant. When dynamic load testing is specified, provide the name of the consultant and a résumé describing at least 3 years' experience in:

(1) Dynamic load testing and analysis;

(2) Signal matching analysis; and

(3) Wave equation analysis including the initial wave equation analysis.

(c) Welders. Provide names and AWS certifications.

551.04 Submittal. At least 30 days before starting driven pile work, submit the following according to Subsection 104.03:

(a) Start date and proposed driven pile construction sequence;

(b) Wave equation analysis report. Include a wave equation analysis for the proposed pile driving system, unless the use of the dynamic formula is specified to determine the nominal driven pile capacity;

(c) Equipment and analysis. Furnish the following pile-driving equipment information:

(1) General. Project and structure identification, pile-driving Contractor or subcontractor, and auxiliary methods of installation such as jetting or preboring and the type and use of the equipment;

(2) Hammer. Manufacturer, model, type, serial number, rated energy (_____ at _____ length of stroke), ram weight, and modifications;

(3) Capblock (hammer cushion). Material, thickness, area, modulus of elasticity (E), and coefficient of restitution (e);

(4) Pile cap. Helmet weight, bonnet mass, anvil block mass, and drivehead mass;

(5) Pile cushion. Material, thickness, area, modulus of elasticity (E), and coefficient of restitution (e);

(6) Pile. Pile type, length (in leads), mass per linear foot (meter), wall thickness, taper, cross-sectional area, design pile capacity, description of splice, and tip treatment description;

(7)Test pile details. Location, type, estimated tip elevation, minimum allowable embedment, length, capacity, allowable compressive and tensile stresses;

(8) Subsurface conditions. Soil description, soil damping and quake parameters used in analysis, anticipated driving difficulties (if any); and

(9) Bearing graph analysis results. Calculated maximum compressive and tensile stresses, penetration resistance (blow counts), hammer stroke and energy transferred to the pile for a range of nominal soil resistance values.

(d) Splices. Details for pile field splices.

(e) Pile shoes. Details for pile shoes.

551.05 Pile Driving Equipment. Furnish equipment conforming to the following requirements:

(a) Pile hammers.

(1) Gravity hammers. Gravity hammers may only be used to drive timber piles. Furnish a hammer with a ram weighing between 2,000 and 3,500 pounds (900 and 1600 kilograms) and limit the drop height to 12 feet (3.7 meters). Select a ram mass greater than the combined mass of the drive head and pile. Provide hammer guides to ensure concentric impact on the drive head.

(2) Open-end diesel hammers. Equip open-end (single acting) diesel hammers with a device, such as rings on the ram to permit visual determination of hammer stroke. Submit a chart from the hammer manufacturer equating stroke and blows per minute for the hammer to be used. A speed versus stroke calibration may be used if approved.

(3) Closed-end diesel hammers. Submit a chart, calibrated to actual hammer performance within 90 days of use, equating bounce chamber pressure to either equivalent energy or stroke for the hammer to be used. Equip hammers with a dial gauge for measuring pressure in the bounce chamber. Make the gauge readable from ground level. Calibrate the dial gauge to allow for losses in the gauge hose. Verify the accuracy of the calibrated dial gauge during driving operations by ensuring that cylinder lift occurs when bounce chamber pressure is consistent with the maximum energy given in the hammer specifications. Do not use closed-end diesel hammers that do not attain cylinder lift at the maximum energy-bounce chamber pressure relationship given in the hammer specification.

(4) Air or steam hammers. Furnish plant and equipment for steam and air hammers with sufficient capacity to maintain the volume and pressure specified by the hammer manufacturer. Equip the hammer with accurate pressure gauges that are easily accessible. Use a hammer with the mass of the striking parts equal to or greater than one third the combined mass of the driving head and pile. Ensure the combined mass is at least 2,750 pounds (1250 kilograms).

Measure inlet pressures for double-acting and differential-acting air or stream hammers with a needle gauge at the head of the hammer when driving test piles. If required, also measure inlet pressures when driving production piles. A pressure versus speed calibration may be developed for specific driving conditions at the project as an alternative to periodic measurements with a needle gauge.

(5) Nonimpact hammers. Use nonimpact hammers, such as vibratory hammers when specified. Use nonimpact hammers for installing production piles only after the pile tip elevation or embedment length for safe support of the pile load is established by static or dynamic load testing. Control the installation of production piles when using vibratory hammers by power consumption, rate of penetration, specified tip elevation, or other acceptable methods that ensure the required pile load capacity is obtained. Strike piles with an impact hammer of suitable energy to verify the required pile capacity is obtained on at least one of every ten piles.

(6) Hydraulic hammers. Provide a power plant for hydraulic hammers with sufficient capacity to maintain the volume and pressure, specified by the manufacturer, at the hammer under working conditions. Equip the power plant and equipment with accurate pressure gauges that are easily accessible to the CO.

(b) Approval of pile-driving equipment. Furnish pile-driving equipment that permits permanent piles to be driven with reasonable effort and to the required depths and resistances without damage.

Approval of pile-driving equipment will be based on a wave equation analysis unless the contract specifies the dynamic formula to determine the nominal driven pile capacity.

Use only the approved equipment represented in the wave equation analysis during pile-driving operations. Approval of the pile-driving system is specific to the equipment submitted. If the proposed equipment is modified or replaced, re-evaluate and resubmit the analysis and revised data for approval before using. Approval of a pile hammer does not relieve the Contractor of responsibility for piles damaged due to driving stress.

(1) Wave equation. The required number of hammer blows indicated by the wave equation at the nominal pile capacity is between 2 and 10 blows per inch (25 millimeters).

In addition, do not allow the pile stresses resulting from the wave equation analysis to exceed the values at which pile damage is impending. The point of impending damage is defined for steel, concrete, and timber piles as follows.

(a) Steel piles. Limit the compressive driving stress to 90 percent of the yield strength of the pile material.

(b) Concrete piles. Limit the tensile (*TS*) and compressive (*CS*) driving stresses to:

$TS \leq 3f_c'^{1/2} + EPV$ for US Customary $TS \leq 0.25f_c'^{1/2} + EPV$ for Metric

$CS \leq 0.85f_c' - EPV$ for US Customary $CS \leq 0.85f_c' - EPV$ for Metric

where:

f_c' = The 28-day design compressive strength of the concrete in pounds per square inch (megapascals)

EPV= The effective prestress value in pounds per square inch (megapascals)

(c) Timber piles. Limit the compressive driving stress to:

$\sigma_{dr} = \phi_{da}(F_{CO})$ where:

σ_{dr} = limiting driving stress (ksi or kilonewtons)

ϕ_{da} = resistance factor, drivability analysis

F_{CO} = base resistance of wood in compression parallel to the grain (ksi or kilonewtons)

(2) Minimum hammer energy. The energy of the driving equipment submitted for approval, as rated by the manufacturer, will be determined by a wave equation analysis.

(c) Driving appurtenances.

(1) Hammer cushion. Equip impact pile-driving equipment, except gravity hammers, with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniform driving behavior. Fabricate hammer cushions from durable, manufactured material according to the hammer manufacturer's recommendations. Do not use wood, wire rope, or asbestos hammer cushions. Place a striker plate, as recommended by the hammer manufacturer, on the hammer cushion to ensure uniform compression of the cushion material. Inspect the hammer cushion in the presence of the CO when beginning pile driving at each structure or after each 100 hours of pile driving, whichever is less. Replace the cushion when its thickness is reduced by more than 25 percent of its original thickness;

(2) Pile drive head. Provide adequate drive heads for impact hammers. Provide appropriate drive heads, mandrels, or other devices for special piles according to the manufacturer's recommendations. Align the drive head axially with the hammer and pile. Fit the drive head around the pile head so that transfer of torsional forces is prevented during driving and proper alignment of hammer and pile is maintained;

(3) Leads. Support piles in line and position with leads while driving. Construct pile driver leads to allow freedom of movement of the hammer while maintaining axial alignment of the hammer and the pile. Do not use swinging leads unless permitted in writing or specified in the contract. When swinging leads are permitted fit swinging leads with a pile gate at the bottom of the leads and in the case of battered piles, fit with a horizontal brace between the crane and the leads. Adequately embed leads in the ground or constrain the pile in a structural frame (template) to maintain proper alignment. Provide leads of sufficient length that do not require a follower, but will permit proper alignment of battered piles;

(4) Followers. Do not use followers unless approved. When followers are permitted, drive the first pile in each bent or substructure unit and every tenth pile thereafter, full length without a follower, to verify that adequate pile embedment is being attained to develop the required nominal capacity. Provide a follower of such material and dimensions that will permit the piles to be driven to the required penetration. Hold and maintain follower and pile in proper alignment during driving;

(5) Jetting. Do not use jetting unless approved. Provide jetting equipment with sufficient capacity to deliver a consistent pressure equivalent to at least 100 pounds per square inch (700 kilopascals) at two ¾-inch (19-millimeter) jet nozzles. Jet so as not to affect the lateral stability of the final in-place pile. Remove jet pipes when the pile tip is at least 5 feet (1.5 meters) above the prescribed tip elevation, and drive the pile to the required nominal capacity with an impact hammer. Control, treat if necessary, and dispose of jet water in an approved manner;

(6) Pile cushion. For concrete piles, use a new pile cushion to protect the head of each pile. Cut the pile cushion at least 4 inches (100 millimeters) thick and to match the cross-section of the pile top. Replace the pile cushion if it is compressed more than one-half its original thickness or it begins to burn. For steel and timber piles, protect each pile with an approved driving cap. Enclose timber piles with approved collars or bands to prevent splitting or brooming. Replace caps when damaged. Do not reuse cushions or caps; and

(7) Pile shoes. When specified, provide shoes to protect the pile-tip from damage during driving. Fabricate shoes to snugly fit the pile tip. For concrete piles, attach the shoe to the pile using dowels or other approved methods. For steel piles, design and fit the shoe to the steel shape and weld the shoe to the pile so as not to stress the web or the flange. For timber piles, carefully shape the tip to secure an even uniform bearing for the pile shoe. Treat holes, cuts, or caps in treated timber piles with two-brush applications of creosote-coal tar solution according to AWPA.

551.06 Pile Lengths. Furnish piles with sufficient length to obtain the required resistance and to extend into the pile cap or footing as indicated in the plans. In addition, increase the length to provide fresh heading and to provide for the Contractor's method of operation. When test piles are required, furnish piles in the lengths determined by the test piles.

551.07 Test Piles. Install test piles when specified in the contract.

Place the piles designated as dynamic load test piles in a horizontal position and not in contact with other piles. Drill holes for mounting instruments near the head of the pile. Mount the instruments after the pile is in leads and take wave speed measurements. Provide at least a 48- by 48-inch (1200- by 1200-millimeter) rigid platform with a 42-inch (1050-millimeter) safety rail that can be raised to the top of the pile.

Excavate the ground at the site of each test pile or production pile to the elevation of the bottom of the footing before the pile is driven. Furnish test piles longer than the estimated length of production piles. Drive test piles with the same equipment as the production piles.

Drive test piles to the required nominal capacity at the estimated tip elevation. Allow test piles that do not attain the required nominal capacity at the estimated tip elevation to set up for 24 hours before re-driving. Warm the hammer before re-driving begins by applying at least 20 blows to another pile. If the required nominal capacity is not attained on re-driving; drive a portion or the remaining test pile length and repeat the set up and re-drive procedure as directed. Splice and continue driving until the required nominal pile capacity is obtained.

Conform to the requirements for production piles when test piles are to be used in the completed structure. Remove test piles not incorporated in the completed structure to at least 24 inches (600 millimeters) below finished grade.

551.08 Driven Pile Capacity. Drive piles to the specified penetration and to the depth necessary to obtain the required nominal pile capacity. Splice piles not obtaining the required nominal capacity at the ordered length, and drive with an impact hammer until the required nominal pile capacity is achieved.

Use the wave equation to determine nominal pile capacity of the in-place pile.

(a) Wave equation. Adequate penetration will be considered to be obtained when the specified wave equation resistance criteria is achieved within 5 feet (1.5 meters) of the designated tip elevation. Drive piles that do not achieve the specified resistance within these limits to a penetration determined by the CO.

(b) Dynamic formula. Drive the piles to a penetration necessary to obtain the nominal pile capacity according to the FHWA Gates Formula:

$$R_{ndr} = 1.75\sqrt{E_d}\,\log_{10}(10N_b) - 100 \quad \text{(US Customary)}$$

$$R_{ndr} = 7\sqrt{E_d}\,\log_{10}(10N_b) - 550 \quad \text{(Metric)}$$

where:

R_{ndr}	= Nominal pile resistance measured during pile driving in kips (kilonewtons)
E_d	=Developed hammer energy. This is the kinetic energy in the ram at impact for a given blow. If ram velocity is not measured, it may be assumed equal to the potential energy of the ram at the height of the stroke, taken as the ram mass times the stroke (foot-pounds or joules)
$log_{10}(10N_b)$	= Logarithm to the base 10 of the quantity 10 multiplied by N
N_b	= Number of hammer blows per inch (25 millimeters) at final penetration

Determine the in-place nominal capacity of jetted piles based on impact hammer blow counts (dynamic formula) after the jet pipes have been removed. After the pile penetration length necessary to produce the required nominal pile capacity has been determined by impact hammer blow count, install the remaining piles in each group or in each substructure unit to similar depths with similar methods. Confirm the required nominal pile capacity has been achieved by using the dynamic formula.

551.09 Preboring. Use auguring, wet rotary drilling, or other approved methods of preboring.

Prebore the pile hole to natural ground in compacted embankments more than 5 feet (1.5 meters) deep.

In natural ground, preboring may extend to the surface of the rock or hardpan for piles end-bearing on rock or hardpan. Seat the pile into the end-bearing strata.

Stop preboring at least 5 feet (1.5 meters) above the estimated pile tip elevation and drive the pile with an impact hammer to a penetration which achieves the required nominal pile capacity for piles not end-bearing on rock or hardpan. Prebore holes smaller than the diameter or diagonal of the pile cross-section while allowing penetration of the pile to the specified depth.

Increase the hole diameter to the least dimension adequate for pile installation if the subsurface obstructions such as boulders or rock layers are encountered. Fill remaining void space around the pile with sand or other approved material after driving is complete. Do not use a punch or a spud instead of preboring.

Do not impair the capacity of existing piles or the safety or condition of adjacent structures. If preboring disturbs the capacity of previously installed piles or structures, restore the required nominal capacity of piles and structures by approved methods.

551.10 Preparation and Driving. Perform the work under Section 208. Make the heads of piles plane and perpendicular to the longitudinal axis of the pile. Coordinate pile driving to prevent damage to other parts of the completed work.

Drive pile heads to within 3 inches (75 millimeters) of plan location at cutoff elevation for bent caps supported by piles and to within 6 inches (150 millimeters) of plan location from piles capped below final grade. Locate and drive piles at least 4 inches (100 millimeters) from any edge of the cap. Drive piles so that the axial alignment is within ¼ inch per foot (20 millimeters per meter) along the longitudinal axis of the required alignment. The CO may stop driving to check the pile alignment. Check alignment before the last 5 feet (1.5 meters) are driven for piles that cannot be internally inspected after installation. Do not pull laterally on piles or splice to correct misalignment. Do not splice a properly aligned section on a misaligned pile.

Place individual piles in pile groups either starting from the center of the group and proceeding outward in both directions or starting at the outside row and proceeding progressively across the group.

Correct piles driven improperly, driven out of proper location, misaligned, or driven below the designated cutoff elevation in an approved manner. Replace piles damaged during handling or driving. Obtain approval for the proposed methods of correcting or repairing deficiencies.

(a) Timber piles. Do not use piles with checks wider than ½ inch (13 millimeters). Drive treated timber piles within 6 months after treatment. Handle and care for pressure-treated piles according to AWPA, *Standard M 4 Standard For The Care Of Preservative-Treated Wood Products*.

(b) Steel piles. Furnish full-length, un-spliced piles for lengths up to 60 feet (18 meters). If splices are required in the first pile driven and it is anticipated that subsequent piles will also require splices, place the splices in lower third of the pile. Splice lengths less than 10 feet (3 meters) are not permitted and only 2 splices per pile are allowed.

Load, transport, unload, store, and handle steel piles so the metal is kept clean and without damage. Do not use piles that exceed the camber and sweep permitted by allowable mill tolerance. Steel piles damaged during installation are unacceptable unless the minimum tip elevation is obtained and load tests show the bearing capacity is 100 percent of the required nominal. Perform tests on damaged piles at no cost to the Government. If driving points are required, weld driving points to steel piles according to AASHTO/AWS, *Structural Welding Code - Steel D1.1 (D1.1M)* or AWS, *Bridge Welding Code D1.5 (D1.5M)* as applicable.

(c) Precast and prestressed concrete piles. Support concrete piles during lifting or moving at the points shown in the plans. Provide support at the quarter points if not specified. Furnish slings or other equipment when raising or transporting concrete piles to avoid bending the pile or breaking edges.

Reject concrete piles with reduced strength caused by external defects such as spalls, cracks, or internal defects such as cavities revealed with non-destructive testing.

(d) Concrete-filled pipe or steel shell piles. Furnish and handle the steel shells or pipes according to Subsection 551.10(b). Cutting shoes for shells or pipes may be inside or outside the shell. Use high-carbon structural steel with a machined ledge for shell bearing or cast steel with a ledge designed for attachment with a simple weld.

Drive pile shells or pipes for a substructure unit before placing concrete in the shells or pipes when practical. Do not drive pile shells or pipes within 15 feet (5 meters) of concrete-filled pile shell or pipe until the concrete has cured for at least 7 days or 3 days if using high-early-strength concrete. Do not drive pile shell or pipe after it is filled with concrete.

Remove and replace shells that are determined to be unacceptable for use due to breaks, bends, or kinks.

551.11 Splices. Align and connect pile sections so the axis of the spliced pile is straight.

(a) Steel piles. Use welders certified for structural welding.

Make surfaces to be welded smooth, uniform, and without loose scale, slag, grease, or other material that prevents proper welding. Steel may be oxygen cut. Carbon-arc gouging, chipping, or grinding may be used for joint preparation.

Weld according to AASHTO/AWS, *Structural Welding Code - Steel D1.1 (D1.1M)* or AWS, *Bridge Welding Code D1.5 (D1.5M).* Weld the entire pile cross-section using prequalified AWS groove weld butt joints. Weld so there is no visual evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size. Do not use manufactured splices unless approved in writing or shown in the plans. Manufactured splices may be used in place of full penetration groove butt welds if the Contractor can prove they can develop the full strength of the pile in compression, tension and bending.

(b) Concrete pile splices. Use dowels or other acceptable mechanical means to splice precast concrete or precast prestressed concrete piles. Submit drawings of proposed splices for approval.

If dowels are used, cast the dowels into the tip end of the following pile with corresponding holes at the butt end of the driven pile. Serrate the holes to provide a mechanical bond. Separate the ends of the piles by at least ½ inch (13 millimeters). Clean surfaces and dowel holes. Grout the dowels in place and allow the grout to cure. Enclose the gap with forms and inject a bonding agent capable of withstanding the impact and driving forces and having the same compressive strength as the pile. Follow the manufacturer's recommendations regarding the use and curing of grouting and bonding products.

Attach manufactured splices to the concrete piles as recommended by the manufacturer. Ensure the splice develops strengths in compression, tension, and bending equal to or exceeding the strength of the pile being spliced.

(c) Concrete pile extensions.

(1) Precast concrete piles. Extend precast concrete piles by removing the concrete at the end of the pile and leaving 40 diameters of reinforcement steel exposed. Remove the concrete to produce a face perpendicular to the axis of the pile. Securely fasten reinforcement of the same size as that used in the pile to the projecting reinforcing steel. Form the extension to prevent leakage along the pile.

Immediately before placing concrete, wet the top of the pile thoroughly and cover with a thin coating of neat cement, re-tempered mortar, or other suitable bonding material. Place concrete of the same mix design and quality as that used in the pile. Keep forms in place for not less than 7 days after the concrete has been placed. Cure and finish according to Section 552.

(2) Prestressed piles. Extend prestressed precast piles according to Subsection 551.11(b). Include reinforcement bars in the pile head for splicing to the extension bars. Do not drive extended prestressed precast piles.

(d) Timber piles. Do not splice timber piles.

551.12 Heaved Piles. Check for pile heave during the driving operation. Take level readings immediately after each pile is driven and again after piles within a radius of 15 feet (5 meters) are driven. Re-drive piles that heave more than ½ inch (13 millimeters) for end-bearing piles or 1½ inches (38 millimeters) for friction piles. Re-drive to the specified resistance or penetration.

551.13 Pile Load Tests. Pile load tests are not required unless specified.

(a) Dynamic load test. Furnish equipment and perform dynamic load tests according to ASTM D4945 under the supervision of the CO. Mount the instruments according to Subsection 551.07.

Drive the pile to the depth at which the dynamic test equipment indicates that the required nominal pile capacity is achieved. If necessary to maintain stresses in the pile below the values in Subsection 551.03(b)(1), reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer. Realign the driving system if nonaxial driving is indicated.

At least 24 hours after the initial driving, re-drive each dynamic load test pile with instrumentation attached. Warm the hammer before re-driving by applying at least 20 blows to another pile. Re-drive the dynamic load test pile for a maximum penetration of 3 inches (75 millimeters), a maximum of 20 blows, or to practical driving refusal, whichever occurs first. Practical driving refusal is defined as 12 blows per inch (15 blows per 25 millimeters) for steel piles, 10 blows per inch (8 blows per 25 millimeters) for concrete piles, and 5 blows per inch (5 blows per 25 millimeters) for timber piles.

Verify the assumptions used in the initial wave equation analysis submitted according to Subsection 551.03(b) using signal matching analysis. Analyze one blow from the original driving and one blow from the re-driving for each pile tested.

Perform additional wave equation analyses with adjustments based on the signal matching analysis results. Provide a graph showing blow count versus nominal capacity. Provide a blow count versus stroke graph for the nominal capacity of open-ended diesel hammers. Provide the driving stresses, transferred energy, and pile capacity as a function of depth for each dynamic load test.

Based on the results of the dynamic load testing, signal matching analyses, and wave equation analyses, the order list and production driving criteria may be approved and the required cut-off elevations provided, or additional test piles and load testing may be specified. This information will be provided within 7 days after receipt of the order list and required test data for the test piles driven.

(b) Static load tests. Perform static load tests according to ASTM D1143 using the quick load test method, except as modified herein. Submit drawings of the proposed loading apparatus for approval according to the following:

(1) Have a professional engineer prepare the drawings;

(2) Furnish a loading system capable of applying 150 percent of the nominal pile capacity or 1,000 tons (9000 kilonewtons), whichever is less; and

(3) Construct the apparatus to allow increments of load to be placed gradually without causing vibration to the test pile.

Perform test at least 5 days after test pile was driven unless approved by the CO. Drive tension piles at the location of permanent piles when feasible if tension (anchor) piles are required. Do not use timber or tapered piles installed in permanent locations as tension piles. Take the test to plunging failure or the capacity of the loading system, whichever occurs first.

The nominal bearing resistance is defined as 50 percent of the failure load. The failure load is defined as follows:

• For piles 24 inches (600 millimeters) or less in diameter, length of side for square piles or diagonal width, the load that produces a settlement at failure of the pile head equal to:

$$S_f = S + (0.15 + 0.008D) \quad \text{(U.S. Customary)}$$

$$S_f = S + (3.8 + 0.008D) \text{ (Metric)}$$

• For piles greater than 24 inches (600 millimeters) in diameter, length of side for square piles or diagonal width:

$$S_f = S + \frac{D}{30}$$

where:

S_f = Settlement at failure in inches (millimeters)

D = Pile diameter or diagonal width in inches (millimeters)

S = Elastic deformation of pile in inches (millimeters)

Determine top elevation of the test pile immediately after driving and again just before load testing to check for heave. Wait at least 3 days between the driving of anchor or load test piles and the commencement of the load test. Before testing, re-drive or jack to the original elevation piles that heaves more than ¼ inch (6 millimeters).

After completion of the load testing, remove or cut off test or anchor piling not a part of the finished structure at least 24 inches (600 millimeters) below either the bottom of footing or the finished ground elevation.

Based on the results of the static load testing, the order list and production driving criteria may be approved and the required cut-off elevations provided or additional load tests may be specified. This information will be provided within 7 days after receipt of the order list and required test data for the test piles driven.

551.14 Pile Cutoffs. Cut off the tops of permanent piles and pile casings at the required elevation. Cut off the piles clean and straight parallel to the bottom face of the structural member in which they are embedded. Dispose of cutoff lengths according to Subsection 203.05(a).

Treat the heads of treated timber piles which are not embedded in concrete by one of the following methods:

(a) Reduce the moisture content of the wood to no more than 25 percent with no free moisture on the surface. Brush apply one application of creosote-coal tar solution as required in AWPA Standards.

Build up a protective cap by applying alternate layers of loosely woven fabric and hot asphalt or tar, similar to membrane waterproofing, using three layers of asphalt or tar and two layers of fabric. Use fabric at least 6 inches (150 millimeters) wider in each direction than the diameter of the pile. Turn the fabric down over the pile and secure the edges by binding with two turns of No. 10 (3-millimeter) galvanized wire. Apply a final layer of asphalt or tar to cover the wire. Neatly trim the fabric below the wires.

(b) Cover the sawed surface with three applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brush coat with three applications of hot creosote and cover with hot roofing pitch. Place a covering of galvanized sheet metal over the coating and bend down over the sides of each pile.

551.15 Unsatisfactory Piles. Correct unsatisfactory piles by an approved method. Methods of correcting unsatisfactory piles may include one or more of the following:

(a) Use of the pile at a reduced capacity;

(b) Install additional piles;

(c) Repair damaged piles; and

(d) Replace damaged piles.

551.16 Placing Concrete in Steel Shell or Pipe Piles. Clean the inside of shells and pipes by removing loose material after driving. Keep the shell or pipe substantially water tight. Remove water before placing concrete or place the concrete using a tremie when water is present in the pile. Provide suitable equipment for inspecting the entire inside surface of the driven shell or pipe just before placing concrete.

(a) Reinforcing steel. Make the spacing between adjacent cage elements at least five times the maximum size of aggregate in the concrete when reinforcing steel is required.

Securely tie concrete spacers or other approved spacers at fifth points around the perimeter of the reinforcing steel cage. Install spacers at intervals not to exceed 10 feet (3 meters) measured along the length of the cage.

Place the reinforcement cage into the driven shell or pipe when the concrete reaches the planned bottom elevation of the reinforcement. Support the reinforcement so it remains within 2 inches (50 millimeters) of the required vertical location. Support the cage from the top until the concrete reaches the top of the pile.

(b) Concrete. Construct concrete according to Section 552. Place concrete in one continuous operation from the bottom to the top of the pile. Consolidate the top 10 feet (3 meters) of the concrete pile using approved vibratory equipment before the initial concrete set.

551.17 Acceptance. Pile material will be evaluated under Subsections 106.02 and 106.03.

Furnish production certifications with each shipment of the following:

(a) Concrete piles;

(b) Sheet piles, steel H-piles, steel shells, and steel pipes; and

(c) Treated timber piles. Stamp each pile with an identification mark and date of inspection.

Driving piles and related work will be evaluated under Subsections 106.02 and 106.04.

Concrete for steel shells or pipe piles will be evaluated under Section 552.

Reinforcing steel for steel shells or pipe piles will be evaluated under Section 554.

Measurement

551.18 Measure the Section 551 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring piles by the linear foot (meter), measure the length of pile from the cutoff elevation to the tip.

Measure splices required to drive piles deeper than the estimated tip elevation.

Payment

551.19 The accepted quantities will be paid at the contract price per unit of measurement for the Section 551 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 552. — STRUCTURAL CONCRETE

Description

552.01 This work consists of furnishing, placing, finishing, and curing concrete in bridges, culverts, and other structures.

Structural concrete class is designated in the plans according to Table 552-1.

Material

552.02 Conform to the following Section and Subsections:

Coarse aggregate for concrete	703.02
Color coating	725.15
Concrete curing material and admixtures	711
Elastomeric bearing (pads)	717.10(a)
Epoxy resin adhesives	725.18
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Non-shrink grout	725.13(b)
Pozzolans	725.04
Preformed polychloroprene elastomeric joint seal for bridges	712.01(g)
Reinforcing fibers	725.17
Sealants, fillers, and seals	712.01
Water	725.01(a)

Construction Requirements

552.03 Composition (Concrete Mix Design). Design and produce concrete mixtures that conform to Tables 552-1, 552-2, and 552-3 as required for the class specified. Determine design strength values according to Chapter 5 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary*.

Table 552-1
Composition of Concrete

Class of Concrete	Minimum Compressive Strength @ 28-Days, f'c, psi (MPa)	Maximum Water/ Cementitious Material Ratio	Coarse Aggregate Size Number AASHTO M 43 (1)
A	4500 (31.0)	0.45	5, 56, 57
A(AE)	4500 (31.0)	0.45	5, 56, 57
C	4500 (31.0)	0.45	7, 78
C(AE)	4500 (31.0)	0.45	7, 78
D(AE) (2)	5000 (34.5)	0.40	5, 56, 57
P (Prestressed) (3)	See plans	–	6,7,67,68,78
P(AE) (3)	See plans	–	6,7,67,68,78
S (Seal)	–	0.54	5, 56, 57

(1) Meet the processing requirements of AASHTO M 43, *Table 1 – Standard Sizes of Processed Aggregate*.

(2) The maximum water-soluble chloride ion (Cl^-) content is 0.15 percent by mass of cement. Determine the water-soluble chloride ion content of concrete made with mix ingredients at an age between 28 and 48 days according to ASTM C1218. Submit test results with the concrete mix design for approval.

(3) The maximum water-soluble chloride ion (Cl^-) content is 0.06 percent by mass of cement. Determine the water-soluble chloride ion content of concrete made with mix ingredients at an age between 28 and 48 days according to ASTM C1218. Submit test results with the concrete mix design for approval.

Table 552-2
Air Content for Air Entrained Concrete(1)

Nominal Maximum Aggregate Size (2)	Minimum Air Content (3) (%)	Maximum Air Content (3) (%)
1½ inch (37.5 mm)	4.0	7.0
1 inch (25 mm)	4.5	7.5
¾ inch (19 mm)	4.5	7.5
½ inch (12.5 mm)	5.5	8.5

(1) The minimum air content values in the table may be reduced by up to 1.0 percent for concrete with f'_c greater than 5000 pounds per square inch (34.5 megapascals).

(2) Meet the requirements of AASHTO M 43, *Table 1 – Standard Sizes of Processed Aggregate*.

(3) For P(AE) concrete, reduce the as-delivered minimum air content by 1.0 percent and use a maximum air content of 6.0 percent.

Table 552-3
Cementitious Material Requirements for Concrete

Cementitious Material	Maximum Percent of Total Cementitious Material by Mass
Fly ash or other pozzolans, AASHTO M 295	25
Slag, AASHTO M 302	50
Silica fume, AASHTO M 307	10
Total fly ash or other pozzolans, slag, and silica fume	50 (1)
Total fly ash or other pozzolans and silica fume	35 (1)

(1) Limit fly ash or other pozzolans to no more than 25 percent of the total mass of cementitious material and limit silica fume to no more than 10 percent of the total mass of cementitious material.

Submit concrete mix designs on FHWA Form 1608, *552 Structural Concrete Mix Design Submittal*.

Verify mixture design with trial mixes prepared according to ACI 318 from proposed sources or with previous concrete production data for the mixture design submitted from proposed sources. Submit written concrete mix designs for approval at least 36 days before production. Include the following in each mix design submittal:

(a) Project identification;

(b) Name and address of Contractor and concrete producer;

(c) Mix design designation;

(d) Class of concrete and intended use;

(e) Material proportions;

(f) Name and location of material sources for aggregate, cement, admixtures, and water;

(g) Type of cement and other cementitious material if used. Fly ash, ground granulated blast-furnace slag, or silica fume may partially replace cement in the mix. Follow the cement replacement limits in Table 552-3;

(h) Cement content in pounds per cubic yard (kilograms per cubic meter) of concrete;

(i) The saturated surface dry batch mass of the coarse and fine aggregate in pounds per cubic yard (kilograms per cubic meter) of concrete;

(j) Water content in pounds per cubic yard (kilograms per cubic meter) of concrete;

(k) Water/cementitious material ratio. The water/cementitious material ratio for modified concrete is the ratio of the mass of water to the combined masses of hydraulic cement and cement substitute;

(l) Dosage of admixtures. Provide a qualified person from the admixture manufacturer to help establish the proper dosage when requested by the CO. Do not mix chemical admixtures together in a mix unless they are compatible. Furnish supporting documentation of compatibility from the manufacturers.

(1) Air-entraining admixtures. Entrained air may be obtained with either air-entraining hydraulic cement or air-entraining admixture.

(2) Set accelerating admixtures. Do not use chloride accelerators. Do not use set accelerating admixtures in prestressed concrete applications.

(3) Hydration stabilizing admixtures. Hydration stabilizing admixtures may be used to extend the allowable delivery time for concrete. Base the dosage on the time needed to delay the initial set of the concrete for delivery and discharge on the job. Include the design discharge time limit in the dosage submittal. The maximum allowable design discharge time is 3½ hours;

(m) Fine and coarse aggregate quality;

(n) Sieve analysis of fine and coarse aggregate;

(o) Absorption of fine and coarse aggregate;

(p) Bulk specific gravity (dry and saturated surface dry) of fine and coarse aggregate;

(q) Dry rodded density of coarse aggregate in pounds per cubic foot (kilograms per cubic meter.);

(r) Fineness modulus (FM) of fine aggregate;

(s) Material certifications for cementitious material, admixtures, and aggregate;

(t) Target values for concrete slump with and without high-range water reducers;

(u) Target values for concrete air content. Include the proposed range of air content for concrete to be incorporated into the work. Describe the methods by which air content will be monitored and controlled;

(v) Concrete density;

(w) Specified design strength (f'_c) and required average strength (f'_{cr}) for the concrete mixture at 28 days as determined by the process described in Chapter 5 of ACI 318. This process and associated calculations are outlined on FHWA Form 1608, pages 4 and 5. Pending 28-day strength results, a mix design may be approved on the basis that 7-day compressive strength results meet or exceed 85 percent of the required average strength (f'_{cr}) at 28 days;

(x) Compressive strengths test results at 7 and 28 days according to Table 552-9, note (3); and

(y) Material samples if requested.

Do not begin production until the mix design is approved by the CO.

Furnish a new mix design for approval if there is a change in a source of material or when the fineness modulus of the fine aggregate changes by more than 0.20.

552.04 Handling and Storing Material. Handle and store material in a manner that prevents segregation, contamination, or other harmful effects. Do not use cement and fly ash containing evidence of moisture contamination. Store and handle aggregate in a manner that ensures uniform moisture content at the time of batching.

552.05 Measuring Material. Batch the concrete according to the approved mix design and the following tolerances:

(a) Cement	±1 percent
(b) Water	±1 percent
(c) Aggregate	±2 percent
(d) Additive	±3 percent

552.06 Batching Plant, Mixers, and Agitators. Use a batching plant, mixer, and agitator conforming to AASHTO M 157.

552.07 Mixing. Mix the concrete in a central-mix plant or in truck mixers. Operate equipment within manufacturer's recommended capacity. Produce concrete of uniform consistency.

(a) Central-mix plant. Dispense liquid admixtures through a controlled flowmeter. Use dispensers with sufficient capacity to measure, at one time, the full quantity of admixture required for each batch. If more than one admixture is used, dispense each with separate equipment.

Charge the coarse aggregate, one-third of the water, and all air-entraining admixture into the mixer first, then add remainder of the material.

Mix for at least 50 seconds. Begin mixing time after all cement and aggregate are in the drum. Add the remaining water during the first quarter of the mixing time. Add 4 seconds to the mixing time if timing starts the instant the skip reaches its maximum raised position. Transfer time in multiple-drum mixers is included in mixing time. Mixing time ends when the discharge chute opens.

Remove the contents of an individual mixer before a succeeding batch is charged into the drum.

(b) Truck mixer. Do not use mixers with blades worn 1 inch (25 millimeters) or more below the original manufactured height. Do not use mixers and agitators with accumulated hard concrete or mortar in the mixing drum.

Add admixtures to the mix water before or during mixing.

Charge the batch into the drum so a portion of the mixing water enters before the cement.

Mix each batch of concrete according to AASHTO M 157.

552.08 Delivery. Produce and deliver concrete to permit a continuous placement with no concrete achieving initial set before the remaining concrete being placed adjacent to it. Deliver, handle, and place concrete so as to minimize rehandling of the concrete and prevent damage to the structure.

Do not place concrete that has developed an initial set. Do not re-temper concrete by adding water.

If a hydration stabilizing admixture is approved for use in the concrete mix, deliver and place the concrete within the approved design discharge time limit. Limit the slump loss to no more than 2 inches (50 millimeters) during the stabilization period. An approved and compatible hydration activator may be used at the discharge site to ensure proper placement and testing.

(a) Truck mixer/agitator. Use the agitating speed for rotation after mixing. When a truck mixer or truck agitator is used to transport concrete that is completely mixed in a stationary central construction mixer, mix during transportation at manufacturer's recommended agitating speed. Do not exceed 100 total revolutions at mixing speed, including both initial mixing and remixing.

If the concrete has not obtained an initial set, water and admixtures in the approved mix design may be added one time at the project to obtain the required slump or air content. Limit the total of water in the mix so as not to exceed the maximum water/cementitious material ratio of the approved mix design. Remix the concrete and added water or admixtures with 30 revolutions at mixing speed. After the initial introduction of mixing water to cement or cement to aggregates, complete the remixing within the time specified in Table 552-4. After the beginning of the addition of the cement, complete the discharge of the concrete within the time specified in Table 552-5.

Table 552-4
Concrete Remixing and Discharge Time Limits

Cement Type (1)	Admixtures	Remixing Time Limit (hour)	Discharge Time Limit (hour)
Type I, IA, II, IIA, V, or approved blended hydraulic cement	None	0.75	1.00
Type I, IA, II, IIA, V, or approved blended hydraulic cement	AASHTO M 194, Type B, D, or G	1.25	1.50
Type I, IA, II, IIA, V, or approved blended hydraulic cement	Hydration stabilizer	3.00	Approved design discharge time limit, 3.50 maximum
Type III	None	0.50	0.75
Type III	AASHTO M 194, Type B, D, or G	1.00	1.25

(1) AASHTO M 85 or AASHTO M 240 as applicable.

(b) Non-agitating equipment. Non-agitating equipment may be used to deliver concrete if the concrete discharge is completed within 20 minutes from the beginning of the addition of the cement to the mixing drum. Use equipment with smooth, mortar tight, metal containers capable of discharging the concrete at a controlled rate without segregation. Provide covers when needed for protection.

552.09 Quality Control of Mix. Submit and follow a quality control plan according to Sections 153 and 154 as applicable and the following:

(a) Mixing. Designate a certified concrete technician at the mixing plant to be responsible for the mixing operations and quality control including:

(1) Proper storage and handling of components of the mix;

(2) Proper maintenance and cleanliness of plant, trucks, and other equipment;

(3) Sampling and testing according to Table 552-9;

(4) Adjusting the mix proportions to maintain the required water/cementitious material ratio;

(5) Computing batch masses for each day's production;

(6) Checking of the plant's calibration; and

(7) Completing batch tickets. Include the following:

(a) Concrete supplier;

(b) Ticket serial number;

(c) Date and truck number;

(d) Contractor;

(e) Structure or location of placement;

(f) Mix-design and concrete class;

(g) Component quantities and concrete total volume;

(h) Moisture corrections for aggregate moisture;

(i) Total water in mix at plant;

(j) Time of batching and time at which discharge must be completed;

(k) Maximum water that may be added to the mix at the project; and

(l) If a hydration stabilizing admixture is used, the slump at the plant after adding the stabilizer.

Provide equipment necessary for the above tests and controls. Furnish copies of work sheets for (3), (4), (5), and (7) above as they are completed.

(b) Delivery and sampling. Designate at least one certified concrete technician at the project to be responsible for concrete delivery, discharge, and sampling including:

(1) Verifying adjustments to the mix comply with the specifications before discharge;

(2) Completing the batch ticket for each load by, recording the apparent water/cementitious material ratio and the time;

(3) Sampling and testing according to Table 552-9; and

(4) If hydration stabilizing admixture is used, determining the slump before placement. Do not use concrete with a slump loss of more than 2 inches (50 millimeters) as compared to the slump recorded at the batch plant.

552.10 Temperature and Weather Conditions. Maintain the temperature of the concrete mixture just before placement between 50 and 90 °F (10 and 32 °C), except for bridge decks between 50 and 80 °F (10 and 27 °C).

(a) Cold weather. Cold weather is defined as a period when for more than 3 consecutive days the following conditions exist:

(1) Average of the highest and the lowest temperatures occurring during the period from midnight to midnight is less than 40 °F (5 °C); and

(2) Air temperature is not greater than 50 °F (10 °C) for more than one-half in a 24-hour period.

When cold weather is reasonably expected or has occurred within 7 days of anticipated concrete placement; submit a detailed plan for the producing, transporting, placing, protecting, curing, and temperature monitoring of concrete during cold weather. ACI 306, *Guide to Cold Weather Concreting* may be used for guidance in developing the plan. Include procedures for accommodating abrupt changes in weather conditions. Do not start placement until the plan is accepted. Allow at least 3 day for review and approval of the plan.

Have material and equipment required for protection available at the project before commencing cold weather concreting.

Remove snow, ice, and frost from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. Heat surfaces that come into contact with fresh concrete to at least 35 °F (2 °C) and maintain the temperature of these surfaces at 35 °F (2 °C) or above during concrete placement.

Place heaters and direct ducts so as not to cause concrete drying or fire hazards. Vent exhaust flue gases from combustion heating units to the outside of enclosures. Heat the concrete components in a manner that is not detrimental to the mix. Do not heat cement or permit the cement to come into contact with aggregates that are hotter than 100 °F (40 °C). Do not heat aggregates with a direct flame or on sheet metal over fire. Do not heat fine aggregate by direct steam. Do not add salts to prevent freezing.

Protect concrete for at least 72 hours according to Table 552-5. Protect concrete exposed in the final construction for at least 7 days according to Table 552-5.

Furnish and place continuously recording surface temperature measuring devices that are accurate within ±2 °F (±1 °C).

At the end of the protection period, allow the concrete to cool gradually over 24 hours at a rate not to exceed the maximum values shown in Table 552-5. Remove protection when the concrete surface temperature is within 25 °F (15 °C) of the ambient air temperature.

Table 552-5
Cold Weather Concrete Surface Temperatures

Minimum Section Size Dimension	< 12inches (< 300 mm)	12 – 36 inches (300 – 900 mm)	36 – 72 inches (900 – 1800 mm)	> 72 inches (> 1800 mm)
Minimum temperature of concrete during protection period	55 °F (13 °C)	50 °F (10 °C)	45 °F (7 °C)	40 °F (5 °C)
Maximum allowable temperature drop in a 24-hour period after end of protection	50 °F (28 °C)	40 °F (22 °C)	30 °F (17 °C)	20 °F (11 °C)

(b) Hot weather. Hot weather is defined as any time during the concrete placement when the ambient temperature at the work site is above 90 °F (35 °C).

Cool surfaces that come in contact with the mix to below 90 °F (35 °C) by covering with wet burlap or cotton mats, fog spraying with water, covering with protective housing, or by other approved methods.

During placement, maintain concrete temperature by using any combination of the following:

(1) Shade the material storage areas or production equipment;

(2) Cool aggregate by sprinkling; and

(3) Cool aggregate and water by refrigeration or replacing a portion or all of the mix water with flaked or crushed ice to the extent that the ice completely melts during mixing of the concrete.

(c) Evaporation. When placing concrete in bridge decks or other exposed slabs, limit expected evaporation rate to less than 0.1 pound per square foot (0.5 kilograms per square meter) per hour as determined by Figure 552-1.

When necessary, take one or more of the following actions:

(1) Construct windbreaks or enclosures to effectively reduce the wind velocity throughout the area of placement;

(2) Use fog sprayers upwind of the placement operation to effectively increase the relative humidity; and

(3) Reduce the temperature of the concrete according to Subsection 552.10(b).

(d) Rain. Protect the concrete from rain during and after placement.

552.11 Handling and Placing Concrete. Perform the work under Section 208, except for work under Section 258. Construct reinforcing steel, structural steel, bearing devices, joint material, and miscellaneous items according to the appropriate Sections.

(a) General. Design and construct falsework and forms according to Section 562. Remove mortar, debris, and foreign material from the forms and reinforcing steel. Do not place concrete until the forms, embedded material, and the adequacy of the foundation material have been inspected. Thoroughly moisten the forms and subgrade immediately before concrete is placed against them. Use an approved form release agent to produce a minimum of staining, air holes, and hydration discoloration.

Handle, place, and consolidate concrete by methods that do not cause segregation and will result in dense homogeneous concrete that is free of voids and rock pockets. Do not displace reinforcing steel or other material that is to be embedded in the concrete during concrete placement. Do not retemper concrete by adding water to the mix. Use temporary form spreader devices until concrete placement precludes their need.

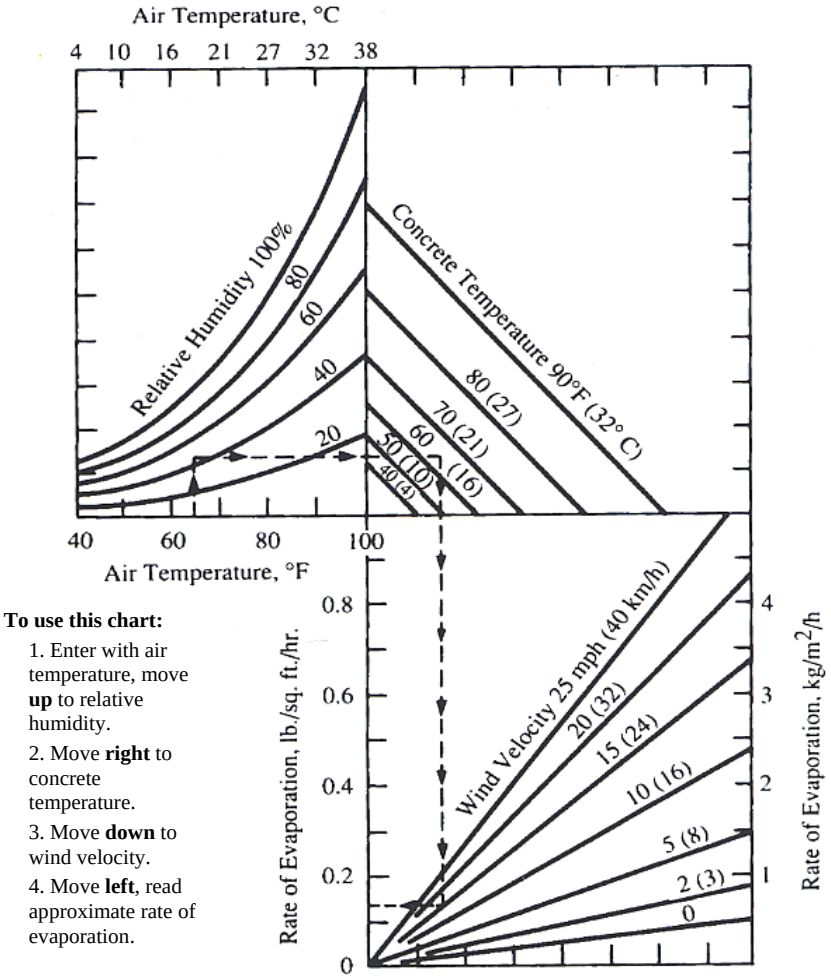

Figure 552-1
Evaporation Rate of Surface Moisture

Note: Example shown by dashed lines is for an air temperature of 65 °F (18 °C), relative humidity of 45 percent, concrete temperature of 65 °F (18 °C), and a wind velocity of 15 miles (24 kilometers) per hour. This results in a rate of evaporation of 0.13 pounds per square foot (0.63 kilograms per square meter) per hour.

Place concrete continuously without interruption between planned construction or expansion joints. Control the delivery rate, placing sequence, and construction methods to ensure fresh concrete is always placed and consolidated against previously placed pre-initial set concrete. Do not allow time between the placement of successive batches to exceed 30 minutes.

Do not damage previously placed concrete or break the bond between the concrete and reinforcing steel. Keep workers off fresh concrete. Do not support platforms for workers and equipment directly on reinforcing steel. Once the concrete is set, do not disturb the forms or reinforcing bars that project from the concrete until it is of sufficient strength to resist damage.

(b) Sequence of placement.

(1) Substructures. Do not place loads on finished bents, piers, or abutments until concrete cylinder tests from the same concrete cured under the same conditions as the substructure element indicate that the concrete has at least 80 percent of its required 28-day compressive strength.

(2) Vertical members. For vertical members less than 15 feet (4.5 meters) in height, allow the concrete to set for at least 30 minutes before placing integral horizontal members. For vertical members over 15 feet (4.5 meters) in height, allow the concrete to set for at least 12 hours. Do not transfer loads from horizontal members until the concrete has reached the specified strength and has been in place at least 7 days.

Do not mount friction collars or falsework brackets on vertical members until the concrete has cured for at least 7 days or has reached specified strength.

(3) Superstructures. Place concrete in the superstructure only after the substructure forms are stripped to allow inspection of the supporting concrete.

For concrete placed in T-beams or deck girders with depths greater than 48 inches (1200 millimeters), allow 5 days cure time for the stem concrete before placement of the top or deck slab.

For box girders, place the bottom slab and stems in one or separate placements. Do not place the top slab until the stems have 5 days cure time.

(4) Arches. Place concrete for arches in alternate lateral sections to minimize shrinkage stresses. Take into account deflections of the arch centering. Place other sections symmetrically with respect to the center of the bridge span. Where wide barrel arches require a longitudinal joint, place concrete on each side of such joint independently of the centering to avoid relative settlements. Bond the sections together with suitable keys or dowels.

(5) Box culverts. Place the box culvert base slab and allow 24 hours before the remainder of the culvert is constructed.

(6) Precast elements. Place and consolidate concrete so that shrinkage cracks are not produced in the member.

(c) Placing methods. Use equipment of sufficient capacity that is designed and operated to prevent mix segregation and mortar loss. Do not use equipment that causes vibrations that could damage the freshly-placed concrete. Do not use equipment with aluminum parts that come in contact with the concrete. Remove set or dried mortar from inside surfaces of placing equipment.

Place concrete as near as possible to its final position. Consolidate concrete in horizontal layers greater than 18 inches (450 millimeters) thick. Do not exceed the vibrator capacity to consolidate and merge the new layer with the previous layer. Do not place concrete at a rate that exceeds the design loading of the forms.

Do not drop unconfined concrete more than 5 feet (1.5 meters). Concrete may be confined by using a tube fitted with a hopper head or other approved device that prevents mix segregation and mortar spattering. This does not apply to cast-in-place piling or drilled shaft when concrete placement is completed before initial set occurs in the bottom of the piling.

Operate concrete pumps so that a continuous stream of concrete without air pockets is delivered at the tube discharge.

(d) Consolidation. Provide sufficient hand-held internal concrete vibrators or mechanical vibrator gangs suitable for the conditions of concrete placement. Use vibrators conforming to Table 552-6. Provide rubber-coated vibrators when epoxy-coated reinforcement is used.

Provide a spare vibrator at the site in case of breakdown. Use external form vibrators only when the forms have been designed for external vibration and when internal vibration is not possible.

Table 552-6
Hand Held Vibratory Requirements

Head Diameter	Frequency (vibrations/minute)	Radius of Action
¾ – 1½ inches (20 to 40 mm)	9,000 – 15,000	3 – 6 inches (75 – 150 mm)
1¼ – 2½ inches (30 – 65 mm)	8,500 – 12,500	5 – 10 inches (130 – 250 mm)
2 – 3½ inches (50 – 90 mm)	8,000 – 12,000	7 – 14 inches (180 – 350 mm)

Consolidate concrete by mechanical vibration immediately after placement. Manipulate vibrators to thoroughly work the concrete around reinforcement, embedded fixtures, corners, and angles in the forms. Do not cause segregation. Do not consolidate concrete placed underwater. Supplement vibration with spading, as necessary, to ensure smooth surfaces and dense concrete along form surfaces, in corners, and at locations impossible to reach with the vibrators.

Vibrate the concrete at the point of deposit and at uniformly spaced points not farther apart than one and one-half times the radius over which the vibration is visibly effective. Insert vibrators so that the affected vibrated areas overlap. Do not use vibrators to move concrete. Insert vibrators vertically and slowly withdraw from the concrete. Vibrate with sufficient duration and intensity to thoroughly consolidate the concrete, but not to cause segregation. Do not vibrate at one point long enough to cause localized areas of grout to form. Do not vibrate reinforcement.

(e) Underwater placement. Underwater placement of concrete is permitted only for concrete mixtures designed for underwater placement according to Subsection 552.03. Use tremies, concrete pumps, or other approved methods for placement.

(1) Tremies. Use watertight tremies, with a sufficient to ensure that aggregate-induced blockages will not occur Use multiple tremies as required. Make tremies capable of being rapidly lowered to retard or stop the flow of concrete.

Seal the discharge end and fill the tremie tube with concrete at the start of concrete placement. Keep the tremie tube full of concrete to the bottom during placement. If water enters the tube, withdraw the tremie and reseal the discharge end. Maintain continuous concrete flow until the placement is completed.

(2) Concrete pumps. Use pumps with a device at the end of the discharge tube to seal out water while the tube is first being filled with concrete. When concrete flow is started, keep the end of the discharge tube full of concrete and below the surface of the deposited concrete until placement has been completed.

Place underwater concrete continuously from start to finish in a dense mass. Place each succeeding layer of concrete before the preceding layer has taken initial set using more than one tremie or pump if necessary. Keep the concrete surface as horizontal as practical. Do not disturb after placement. Maintain still water at the point of deposit.

Dewater after test specimens cured under similar conditions indicate that the concrete has sufficient strength to resist the expected loads. Remove laitance or other unsatisfactory material from the exposed concrete.

(f) Concrete railings and parapets. Use smooth, tight-fitting, rigid forms. Neatly miter corners. Place concrete railings and parapets after the falsework for the supporting span is released. Remove forms without damaging the concrete. Finish corners to be true, clean-cut, and without cracks, spalls, or other defects.

Cast precast railing members in mortar-tight forms. Remove precast members from molds as soon as the concrete has sufficient strength to be self-supporting. Protect edges and corners from chipping, cracking, and other damage. Cure according to Subsection 552.15(b). The curing period may be shortened when approved; use moist heat, Type III portland cement, or water reducing agents.

552.12 Construction Joints. Provide construction joints at locations shown in the plans. Obtain approval for additional construction joints.

Extend reinforcing steel uninterrupted through construction joints. Embed lap splices or mechanical splices within the concrete. Do not use dowels. At horizontal construction joints, place gauge strips inside the forms along exposed faces to produce straight joint lines.

When the joint is between fresh and newly hardened concrete, rough float the first placement to thoroughly consolidate the surface and leave the surface in a roughened condition. Clean the joint surface of laitance, curing compound, and other foreign material. Use an abrasive blast or other approved method to expose the aggregate on the joint surface. Re-tighten forms where the joint overlaps the first placement. Immediately before placing new concrete, flush the joint surface with water and allow it to dry to a surface dry condition.

When the joint is between existing concrete and a new placement, abrasive blast clean or use other approved methods to remove laitance and foreign material, to expose clean aggregate, and to roughen the joint surface. Before concrete placement, apply approved bonding products to the joint surface according to the manufacturer’s recommendation.

552.13 Expansion and Contraction Joints.

(a) Open joints. Form open joints with a wooden strip, metal plate, or other approved material. Remove the joint forming material without chipping or breaking the corners of the concrete. Do not extend reinforcement across an open joint.

(b) Filled joints. Cut pre-molded expansion joint filler to the shape and size of the surface being jointed. Secure the joint filler on one surface of the joint using galvanized nails or other acceptable means. Splice according to the manufacturer's recommendations. After form removal, remove and neatly cut concrete or mortar that has sealed across the joint. Fill joint gaps ⅛ inch (3 millimeters) or wider with approved filler. Place necessary dowels, load transfer devices, and other devices as shown in the plans or as directed.

(c) Steel joints. Fabricate plates, angles, or other structural shapes accurately to conform to the concrete surface. Set joint opening to conform to the ambient temperature at the time of concrete placement. Securely fasten the joints to keep them in correct position. Maintain an unobstructed joint opening during concrete placement.

(d) Compression joint seals. Use one-piece compression joint seals for transverse joints and the longest practical length for longitudinal joints. Clean and dry joints and remove spalls and irregularities. Apply a lubricant adhesive as a covering film to both sides of the seal immediately before installation. Compress the seal and place it in the joint as recommended by the manufacturer. Make sure the seal is in full contact with the joint walls throughout its length.

Remove and discard seals that are twisted, curled, nicked or improperly formed. Remove and reinstall joint seals that elongate more than 5 percent of their original length when compressed. Remove excess lubricant-adhesive before it dries.

(e) Elastomeric expansion joint seal. Install the joint according to the manufacturer's recommendations and according to the plans.

552.14 Finishing Plastic Concrete. Strike off concrete surfaces that are not placed against forms. Float finish the concrete surface. Remove laitance or thin grout. Carefully tool non-chamfered edges with an edger. Leave edges of joint filler exposed.

Protect the surface from rain damage.

Provide at least two non-sagging and non-vibrating work bridges capable of supporting the workers and equipment during placement, finishing, and curing operations. Place the work bridges at a reasonable height above the concrete surface to not impede worker performance and not touch the finished or fresh concrete surface.

(a) Striking off and floating. For bridge decks or top slabs of structures serving as finished pavements, use an approved power driven finishing machine equipped with a screed that oscillates in a transverse direction. Use hand-finishing methods for irregular areas when approved.

Strike off surfaces. Do not support rails within the limits of the concrete placement without approval.

Set rails or headers on non-yielding supports so the finishing equipment operates without interruption over entire surface being finished. Extend rails beyond both ends of the scheduled concrete placement a sufficient distance to enable finishing machine to finish the concrete being placed.

Set rails the entire length of continuous girder structures before placing deck concrete.

Adjust rails, headers, and strike-off equipment to the required profile and cross-section allowing for anticipated settlement, camber, and deflection of falsework.

Before beginning delivery and placement of concrete, operate the finishing machine over the entire area to be finished to check for excessive rail deflections, deck thickness, reinforcing steel cover, and to verify proper operation of equipment. Make necessary corrections before concrete placement begins.

After placing the concrete, operate finishing machine over the concrete as needed to obtain the required profile and cross-section. Keep a slight roll of excess concrete in front of the cutting edge of the screed at all times. Maintain this excess of concrete to the end of the pour or form and then remove and waste it. Adjust rails or headers as necessary to correct for unanticipated settlement or deflection.

Remove rail supports embedded in the concrete to at least 2 inches (50 millimeters) below the finished surface. Clean the voids of dust and debris using compressed air or other means. Apply approved bonding material in the voids. Fill the voids with fresh concrete of the same type and property as previously placed. Finish the surface with a float, roller or other approved device as necessary to remove local irregularities.

Remove excess water, laitance, or foreign material brought to the surface using a squeegee or straightedge drawn from the center of the slab towards either edge. Do not apply water to the surface of the concrete during finishing operations.

(b) Straightedging. Check slab and sidewalk surfaces. Check the entire surface parallel to the centerline of the bridge with a 10-foot (3-meter) metal straightedge. Overlap the straightedge at least half the length of the previous straightedge placement.

Correct deviations in excess of ⅛ inch (3 millimeters) from the testing edge of the straightedge. For deck surfaces that are to receive an overlay, correct deviations in excess of ¼ inch (6 millimeters).

(c) Texturing. Finish after floating or at a time when finishing operations will not displace aggregate. Produce a skid-resistant surface texture on driving surfaces by grooving. Use one of the following or a combination finishes for other surfaces as required.

(1) Grooved finish. Use a float having a single row of fins or an approved machine designed specifically for sawing grooves in concrete pavements. Space fins ½ to ¾ inch (13 to 20 millimeters) on centers. Make the grooves $^{1}/_{16}$ to $^{3}/_{16}$ inch (2 to 5 millimeters) wide and ⅛ to $^{3}/_{16}$ inch (3 to 5 millimeters) deep. Groove perpendicular to the centerline without tearing the concrete surface or loosening surface aggregate.

If grooves are sawn, cut the grooves approximately ¼ inch (6 millimeters) wide at a spacing of ½ to 1 inch (13 to 25 millimeters).

On bridge decks, discontinue grooving 12 inches (300 millimeters) from curb face and provide a longitudinal troweled finish on the surface of gutters.

(2) Sidewalk finish. Strike off the surface using a strike board and then float the surface. Use an edging tool on edges and expansion joints. Broom the surface using a broom with stiff bristles, broom perpendicular to the centerline from edge to edge with adjacent strokes slightly overlapped. Produce regular corrugations not over ⅛ inch (3 millimeters) in depth without tearing the concrete. Correct porous spots, irregularities, depressions, small pockets, and rough spots while the concrete is plastic. Groove contraction joints at the required interval using an approved grooving tool.

(3) Troweled and brushed finish. Use a steel trowel to produce a slick, smooth surface free of bleed water. Brush the surface with a fine brush using parallel strokes.

(4) Exposed aggregate finish. Strike off the surface using a strike board and then float the surface. Use an edging tool on transverse and longitudinal joints that are against forms or existing pavement. Do not edge transverse joints in a continuous lane pour or longitudinal joints in a continuous dual lane pour.

Broom the surface as soon as the concrete hardens sufficiently to prevent particles of gravel from being dislodged. Use stiff brushes approved by the CO. Exercise care to prevent marring of the surface and cracking or chipping of slab edges or joints. Apply a light spray of retardant to the unfinished surface to facilitate this work if approved.

Broom transversely across the pavement. Pull the loosened semi-stiff mortar off the pavement. Remove the mortar from adjacent pavements. Then broom parallel to the pavement centerline. Continue this operation until a sufficient quantity of coarse aggregate is exposed. Other methods of aggregate exposure, such as using a water spray attachment on a special exposed aggregate broom, will be permitted if satisfactory results are demonstrated.

After curing according to Subsection 552.15(b) or (c), wash the surface with water and brush to remove laitance and cement from the exposed coarse aggregate.

(d) Surface underneath bearings. Finish bearing surfaces to within ⅛ inch (5 millimeters) of plan elevation.

When a masonry plate is to be set:

(1) Directly on the concrete or on filler material less than ⅛ inch (5 millimeters) thick; finish the surface with a float to an elevation slightly above plan elevation. Grind the surface as necessary to provide a full and even bearing after the concrete has set.

(2) On filler material between ¼ and ½ inch (6 to 13 millimeters) thick; finish the surface with a steel trowel. Finish or grind the surface so that it does not vary from a straightedge in any direction by more than ¼ inch (6 millimeters).

(3) On filler material greater than ½ inch (13 millimeters) thick or when an elastomeric bearing pad is to be used; finish the surface to a plane surface free of ridges.

When required under a masonry plate or elastomeric bearing pad, use nonshrink grout. Proprietary products may be used with approval.

(e) Surface underneath waterproofing membrane deck seal. Finish to a smooth surface, free of ridges and other projections.

552.15 Curing Concrete. Begin curing immediately after the free surface water has evaporated and the finishing is complete. If the surface of the concrete begins to dry before the selected cure method can be implemented, keep concrete surface moist using a fog spray without damaging the surface.

Keep surfaces to be rubbed moist after forms are removed. Cure immediately following the first rub.

Cure the top surfaces of bridge decks using the liquid membrane curing compound method combined with the water method. Apply liquid membrane curing compound immediately after finishing. Apply the water cure within 4 hours after finishing.

Cure concrete uninterrupted for at least 7 days. If pozzolans in excess of 10 percent by mass of the hydraulic cement is used in the mix, cure uninterrupted for at least 10 days.

(a) Forms in-place method. For formed surfaces, leave the forms in-place without loosening. If forms are removed during the curing period to facilitate rubbing, only strip forms from those areas able to be rubbed during the same shift. During rubbing, keep the surface of the exposed concrete moist. After the rubbing is complete, continue curing process using the water method for the remainder of the curing period.

(b) Water method. Keep the concrete surface continuously wet by ponding, spraying, or covering with material that is kept continuously and thoroughly wet. Covering material may consist of cotton mats, multiple layers of burlap, or other approved material that does not discolor or otherwise damage the concrete.

Cover the covering material with a waterproof sheet material that prevents moisture loss from the concrete. Use the widest sheets practical. Lap adjacent sheets at least 6 inches (150 millimeters), and tightly seal seams with pressure sensitive tape, mastic, glue, or other approved methods. Secure material so that wind does not displace it. Immediately repair sheets that are broken or damaged.

(c) Liquid membrane curing compound method. Do not use the liquid membrane method on surfaces to receive a rubbed finish. Use on construction joint surfaces is permitted only if the compound is removed by sandblasting before placement of concrete against the joint.

Only use Type 2, white-pigmented liquid membrane on the top surfaces of bridge decks or on surfaces not exposed to view in the completed work. Use Type 1-D clear curing compounds on other surfaces and on colored concrete.

Mix membrane curing solutions containing pigments before use. Continue to agitate during application. Use equipment capable of producing a fine spray. Apply the curing compound at a minimum rate of 1 gallon per 150 square feet (0.25 liters per square meter) in one or two uniform applications. If the solution is applied in 2 applications, follow the first application with the second application within 30 minutes, and apply at right angles to the first application.

Immediately apply a new coat over the damaged areas if the membrane is damaged by rain or other means during the curing period.

552.16 Finishing Formed Concrete Surfaces. Remove and replace or repair, as approved, rock pockets or honeycombed concrete. Finish sound, formed concrete surfaces as follows:

(a) Class 1 – Ordinary surface finish. Finish the following surfaces with a Class 1, ordinary surface finish:

(1) Under surfaces of slab spans, box girders, filled spandrel arch spans, and the roadway deck slab between superstructure girders;

(2) Inside vertical surface or T-girders of superstructures; and

(3) Surfaces to be buried and culvert surfaces above finished ground that are not visible from the traveled way or a walkway.

Begin finishing as soon as the forms are removed. Remove fins and irregular projections from surfaces that are exposed or will be waterproofed. Remove bulges and offsets with carborundum stones or discs. Remove localized, poorly-bonded rock pockets or honeycombed concrete, and replace with sound concrete or packed mortar in an approved manner.

Clean and point form tie cavities, holes, broken corners and edges, and other defects. Saturate the area with water. Finish the area with mortar that is less than 1-hour old. After the mortar is set, rub it (if required) and continue curing. Match exposed surfaces to surrounding concrete.

Carefully tool and remove free mortar and concrete from construction and expansion joints. Leave joint filler exposed for its full length with clean, true edges.

Rub or grind bearing surfaces on piers and abutments to the specified elevation and slope.

If the final finished surface is not true and uniform, rub it according to Subsection 552.16(b).

(b) Class 2 – Rubbed finish. Finish the following surfaces with a Class 2, rubbed finish:

(1) Surfaces of bridge superstructures, except those surfaces designated to receive a Class 1 or other finish;

(2) Surfaces of bridge piers, piles, columns and abutments, and retaining walls above finished ground and to at least 12 inches (300 millimeters) below finished ground;

(3) Surfaces of open spandrel arch rings, spandrel columns and abutment towers;

(4) Surfaces of pedestrian undercrossings, except floors and surfaces to be covered with earth;

(5) Surfaces above finished ground of culvert headwalls and endwalls when visible from the traveled way or walkway;

(6) Inside surfaces of culvert barrels higher than 48 inches (1200 millimeter) that are visible from the traveled way. Finish for a distance inside the barrel at least equal to the height of the culvert; and

(7) Surfaces of railings.

Complete a Class 1 finish according to Subsection 552.16(a). Saturate the concrete surface with water. Rub the surface with a medium coarse carborundum stone using a small quantity of mortar on its face. Use mortar composed of cement and fine sand mixed in the same proportions as the concrete being finished. Continue rubbing until form marks, projections, and irregularities are removed and a uniform surface is obtained. Leave the paste produced by this rubbing in place.

After other work which could affect the surface is complete; rub with a fine carborundum stone, and water until the entire surface has a smooth texture and uniform color. After the surface has dried; rub it with burlap to remove loose powder. Leave the surface without unsound patches, paste, powder, and objectionable marks.

(c) Class 3 – Tooled finish. Do not use mortar blocks or wires to set reinforcing steel near the formed surface of areas to receive a tooled finish. Complete a Class 1 finish according to Subsection 552.16(a). Let the concrete set for at least 14 days or longer if necessary to prevent the aggregate particles from being picked out of the surface. Use air tools (such as a bush hammer, pick, or crandall). Chip away the surface mortar, and break the aggregate particles to expose a grouping of broken aggregate particles in a matrix of mortar. Produce a tooled finish on a small test area for approval before proceeding. Adjust the work procedures to produce a satisfactory finish and use those same procedures to finish the designated area.

(d) Class 4 – Sandblasted finish. Complete a Class 1 finish according to Subsection 552.16(a). Let the concrete cure for at least 14 days. Protect adjacent surfaces that are not to be sandblasted. Sandblast a small test area for approval before proceeding. Use hard, sharp sand to produce an even fine-grained surface in which the mortar is cut away leaving the aggregate exposed. Do not remove mortar beyond one-third the diameter of the coarse aggregate.

(e) Class 5 – Wire brushed or scrubbed finish. Complete a Class 1 finish according to Subsection 552.16(a). Begin as soon as the forms are removed. Scrub the surface with stiff wire or fiber brushes using a solution of muriatic acid. Mix the solution in the proportion of 1 part acid to 4 parts water. Scrub until the cement film or surface is completely removed and the aggregate particles are exposed. Leave an evenly pebbled texture having the appearance of fine granite to coarse conglomerate depending upon the size and grading of aggregate. Wash the entire surface with water containing a small quantity of ammonia.

(f) Class 6 – Color finish. Build a sufficient number of 24- by 48-inch (600- by 1200-millimeter) concrete color sample panels to obtain a color acceptable to the CO. Protect the approved color sample panel. Color designated surfaces to match the color of the approved sample.

Complete a Class 1 finish according to Subsection 552.16(a). Do not apply the color finish until concrete placement for the structure is complete. Remove dust, foreign matter, form oil, grease, and curing compound with a 5 percent solution of trisodium phosphate and then rinse the concrete surface with clean water.

Use paper, cloth, or other means to protect surfaces not to be color finished. Apply the finish to a dry concrete surface when the surface temperature is 40 °F (4 °C) or higher and the air temperature in the shade is anticipated to be 40 °F (4 °C) or higher during the 24 hours following application.

Apply the color finish according to the manufacturer’s recommendations. Spray, brush, or roll on the first coat of penetrating sealer and color base. Spray, brush, or roll on the finish coat after the first coat has thoroughly dried. Apply finish to provide a uniform, permanent color, without runs and sags to the surfaces.

Clean concrete areas not intended to be covered by the finish using an approved method.

552.17 Concrete Anchorage Devices. Use chemical, grouted, or cast-in-place concrete anchorage devices for attaching equipment or fixtures to concrete.

Furnish the following for approval:

(a) Concrete anchorage device sample;

(b) Manufacturer's installation instructions; and

(c) Material data and certifications.

Fabricate metal parts of the anchorage devices from stainless steel or from steel protected with a corrosion resistant metallic coating that does not react chemically with concrete. Supply anchorage devices complete with hardware.

For chemical or grouted anchors, conduct a system approval test on one anchor on the project, not to be incorporated in the work. Conduct a static load test according to ASTM E488. Demonstrate that the anchorage device can withstand a sustained direct tension test load not less than the values shown in Table 552-7 for at least 48 hours with movement not to exceed $^{1}\!/_{32}$ inch (1 millimeter). Also demonstrate that when loaded to failure, the anchor device demonstrates a ductile failure of the anchor steel, not a failure of the chemical, grout, or concrete.

Table 552-7
Sustained Load Test Values

Anchorage Device Stud Size	Tension Test Load
¾ inch (M20)	5,000 lb (24 kN)
⅝ inch (M16)	4,100 lb (18.3 kN)
½ inch (M12)	3,200 lb (12.7 kN)
⅜ inch (M8)	2,100 lb (7.1 kN)

Install concrete anchorage devices as recommended by the device manufacturer and so that the attached equipment or fixtures bear firmly against the concrete. Torque installed nuts to the values specified in Table 552-8 unless otherwise specified in the manufacturer's instructions. Set bearing anchor bolts according to the requirements of Section 564.

In the presence of the CO, proof load a random sample of at least 10 percent of the anchors to 90 percent of the yield stress of the steel. If an anchor fails, reset the failed anchor and proof load the reset anchor and 100 percent of remaining anchors. The proof load may be applied by torqueing against a load indicator washer, applying a direct tension load to the anchor, or another method approved by the CO. After proof loading, release the load on the anchor and retighten the nuts to the torque specified in Table 552-8 or according to the manufacturer's instructions.

Table 552-8
Torque for Anchorage Devices

Anchorage Device Stud Diameter	Torque
¾ inch (M20)	125 ft•lb (180 N•m)
⅝ inch (M16)	90 ft•lb (130 N•m)
½ inch (M12)	60 ft•lb (80 N•m)
⅜ inch (M8)	35 ft•lb (30 N•m)

552.18 Loads on New Concrete Structures. Do not allow traffic on concrete bridge decks until deck concrete has attained the design compressive strength and has been in place 14 days or longer. Construction loads less than 4000 pounds (1800 kilograms) may be placed on the deck 7 days after the concrete is placed and the concrete in the entire span has attained a compressive strength of at least 70 percent of the specified design strength.

For precast concrete multi-beam sections, do not allow vehicles on any span until the grout has attained a strength of 3,000 pounds per square inch (21 megapascals) and tie rods have been tightened.

For post-tensioned concrete structures, do not allow vehicles over 4,500 pounds (2000 kilograms) on any span until the prestressing steel for that span is tensioned, grouted, and cured, the grout has obtained a strength of 3,000 pounds per square inch (21 megapascals), and the tie rods are tightened. Vehicles weighing less than 4,500 pounds (2000 kilograms) may be permitted on a span provided the mass of the vehicle was included in the falsework design.

552.19 Concrete Repair. For concrete repairs, remove existing or new defective concrete according to Subsection 203.04(b) and (c). After removal of deteriorated or unsound concrete, shotblast exposed structural steel, reinforcing steel, and concrete surfaces which will be in contact with repair material until free of rust and foreign material. Clean the sound concrete surface by flushing with clean water from a high pressure water jet or compressed air. Remove and replace deteriorated reinforcing steel. Before placing repair concrete, thoroughly flushing with clean water under pressure or compressed air. If compressed air is used, provide a filter in airline to ensure that the air is oil-free. If there is an interval of more than 24 hours between cleaning of the sound concrete surfaces that have been contaminated by substances detrimental to good bonding, clean by abrasive shot blasting and pressurized water flushing or remove the concrete.

For vertical and overhead concrete repairs and those horizontal repairs to areas less than 5 inches (130 millimeters) in depth; use a non-shrink grout patching compound placed according to the manufacturer’s recommendations.

For other repairs patches greater than 5 inches (130 millimeters) in depth, apply a bonding coat of a epoxy resin adhesive to the surfaces of the sound existing concrete immediately before placing new concrete against it. Follow the manufacturer’s recommendations for the epoxy resin adhesive. Repair areas using Class A(AE) concrete.

552.20 Acceptance. See Table 552-9 for sampling, testing, and acceptance requirements and the quality characteristic category.

Material for concrete will be evaluated under Subsections 106.02 and 106.03. Furnish production certifications with each shipment cementitious material.

The concrete mixture's slump, air content, density, and temperature will be evaluated under Subsections 106.02 and 106.04.

Concrete compressive strength will be evaluated under Subsection 106.05. The lower specification limit is the minimum required compressive strength at 28 days (f_c') specified in the contract. Remove and replace concrete represented by cylinders having a compressive strength less than 90 percent of the minimum 28-day strength (f'_c).

Construction (including batching, placing, finishing, and curing concrete) of concrete structures will be evaluated under Subsections 106.02 and 106.04.

Falsework and forms will be evaluated under Section 562.

Measurement

552.21 Measure the Section 552 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring structural concrete by the cubic yard (cubic meter), measure in the structure.

Payment

552.22 The accepted quantities will be paid at the contract price per unit of measurement for the Section 552 pay items listed in the bid schedule, except the structural concrete contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for structural concrete will be made at a price determined by multiplying the contract price by the compressive strength pay factor.

Table 552-9
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (703.02)	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsection 703.01 & 703.02	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Concrete composition	"	All	–	Subsection 552.03	1 per mix design	"	If requested	"	–
Production									
Produced aggregate (fine & coarse)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–

Table 552-9 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Concrete (552.09(b))[1]	Measured and tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load after at least 0.25 yd^3 (0.2 m^3) is discharged[4]	Point of discharge	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump	–	AASHTO T 119	"	"	No	"	–
		Temperature	–	ASTM C1064	"	"	No	"	–
Concrete (552.09(b))[1]	Statistical (106.05)	Compressive strength[2][3] (28-day)	II	AASHTO T 23 & T 22	1 set per 30 yd^3 (25 m^3), but not less than 1 per day and not less than 5 sets total	Discharge stream at point of placing	Yes	28 days	Deliver verification cylinders to the CO or designated laboratory for scheduled testing

(1) Sample according to AASHTO R 60, except composite samples are not required.
(2) Cast at least four compressive strength test cylinders for 6- by 12-inch (150- by 300-millimeter) specimens or six compressive strength cylinders for 4- by 8-inch (100- by 200-millimeter) and carefully transport the cylinders to the job site curing facility.
(3) A single compressive strength test result is the average result from two 6- by 12-inch (150- by 300-millimeter) or three 4- by 8-inch (100- by 200-millimeter) cylinders cast from the same load.
(4) If three successive samples are tested and compliance to the specifications is indicated, screening tests may be reduced to an approved frequency. Resume initial testing frequency if a test shows a failing temperature, air content, slump, or when directed.
(5) If the point of placement is different from the point of discharge, correlate the discharge tests with the placement tests to document the changes.

Section 553. — PRESTRESSED CONCRETE

Description

553.01 This work consists of prestressing precast or cast-in-place concrete by furnishing, placing, and tensioning prestressing steel. This work also includes installing precast, prestressed members, except piling.

Material

553.02 Conform to the following Section and Subsections:

Anchorage devices	722.01
Elastomeric bearing (pads)	717.10(a)
Grout for post-tensioned structures	725.13(c)
Prestressing steel	709.02
Reinforcing steel	709.01
Structural concrete	552

Construction Requirements

553.03 Qualifications. Submit the following for approval at least 30 days before prestressed concrete operations begin:

(a) Professional engineer. Name of the engineer who is certified by PCI for Plant Quality Personnel, Level I or higher and is not directly employed by the precast concrete manufacturing plant;

(b) Precast concrete manufacturing Plant and Quality Control Manager. Name and appropriate certifications;

(c) Grouting supervisor. Name and a résumé describing experience on projects of similar complexity and American Segmental Bridge Institute (ASBI) grouting certification; and

(d) Grouting personnel. Names and a résumé describing their experience on projects of similar complexity.

553.04 Method Approval. Perform prestressing by either pre-tensioning or post-tensioning methods. If a method is proposed that is not in the contract, submit detailed drawings of the method, material, and equipment proposed for approval at least 30 days before starting prestressing. Include the following:

(a) Method and sequence of stressing;

(b) Complete specifications, details, and test results for the prestressing steel and anchoring devices;

(c) Anchoring stresses;

(d) Arrangement of the prestressing steel in the members;

(e) Tendon elongation calculations for jacking procedures to be used;

(f) Number, spacing, and method of draping pre-tensioned strands;

(g) Other substantiating calculations for the prestressing method;

(h) Type of tendon ducts for post-tensioning;

(i) Pressure grouting material and equipment for post-tensioning;

(j) Samples of wire or strand; and

(k) Additions or re-arrangement of reinforcing steel and changes in concrete dimensions.

For on-site casting, submit drawings showing anticipated leveling or alterations to the site. After completion of casting, clear the site of equipment and rubbish, and restore it to an acceptable condition.

553.05 Prestressing Steel. Use prestressing steel that is bright and free of corrosion, dirt, grease, wax, scale, rust, oil, or other foreign material that may prevent bond between the steel and the concrete. Do not use prestressing steel that has sustained physical damage or is pitted.

One splice per strand is permitted when single strand jacking is used. When multi-strand jacking is used, splice all the strands or no more than 10 percent of the strands. Use strands having similar properties, from the same source, and having the same "*twist*" or "*lay*". Locate splices outside the casting bed and between members.

Do not weld or ground welding equipment on forms or other steel in the member after the prestressing steel is installed.

Failure of one wire in a 7-wire prestressing strand is acceptable if 85 percent of the required tension load is attained before failure and if the failed strand does not constitute more than 2 percent of the total area of strands in an individual beam or girder.

Extend bars using couplers which, when assembled, have a tensile strength not less than the tensile strength of the bars.

Protect prestressing steel against physical damage, rust, or corrosion. Do not use damaged prestressing steel.

Package prestressing steel to protect it from physical damage and corrosion during shipping and storage. Place a corrosion inhibitor in the package. Use a corrosion inhibitor that has no deleterious effect on the steel, concrete, or bond strength of steel to concrete. Replace or restore damaged packaging.

Mark the shipping package with a statement that the package contains high-strength prestressing steel and a warning to use care in handling. Identify the type, kind, and quantity of corrosion inhibitor used, including the date when placed, safety regulations, and instructions for use. Assign a lot number and tag for identification purposes to wire, strand, anchorage assemblies, or bars shipped to the site.

553.06 Concrete. Construct prestressed concrete according to Section 552. Construct reinforcing steel according to Section 554.

Make at least one set release strength test cylinders according to AASHTO T 23 in addition to those required to determine the 28-day compressive strength. Cure the release strength test cylinders with the concrete member they represent.

Rough cast the top surface of members against which concrete will be cast. Finish surfaces to be covered with a waterproofing membrane deck seal to a smooth surface free of ridges and other projections.

Cure the girder in a saturated atmosphere of at least 90 percent relative humidity. Cure time may be shortened by heating the outside of impervious forms with radiant heat, convection heat, conducted steam, or hot air.

Apply radiant heat by pipes circulating steam, hot oil, hot water, or electric heating elements. Inspect casting beds to ensure uniform heat application. Use a suitable enclosure to contain the heat. Minimize moisture loss by covering exposed concrete surfaces with plastic sheeting or liquid membrane curing compound according to Subsection 552.15. Sandblast curing compound from surfaces to which concrete will be bonded.

Envelop the entire surface with saturated steam. Completely enclose the casting bed with a suitable type of housing, tightly constructed to prevent the escape of steam and exclude outside air. Use steam at 100 percent relative humidity. Do not apply the steam directly to the concrete.

With hot air, the CO will approve the method to envelop and maintain the girder in a saturated atmosphere. Do not allow dry heat to touch the girder surface.

With heat curing methods:

(a) Keep unformed girder surfaces in a saturated atmosphere throughout the curing time.

(b) Embed a thermocouple, linked with a thermometer accurate to ±5 °F (±3 °C), 6 to 8 inches (150 to 200 millimeters) from the top or bottom of the girder on its centerline and near its midpoint.

(c) Monitor with a recording sensor, accurate to ±5 °F (±3 °C), arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle.

(d) Make the temperature record available to the CO.

(e) Heat concrete to no more than 100 °F (38 °C) during the first 2 hours after placing concrete, and increase the temperature no more than 40 °F (22 °C) per hour to a maximum of 160 °F (71 °C).

(f) Cool concrete, after curing is complete, no more than 40 °F (22 °C) per hour until a temperature 20 °F (11 °C) above the temperature of the air to which the concrete will be exposed has been reached.

(g) Keep the temperature of the concrete above 60 °F until the girder reaches release strength.

Cure precast, prestressed members to the release compressive strength. This is when the average strength of two representative test cylinders is greater than the minimum required strength and the individual strength of any one cylinder is no more than 5 percent below the required strength.

553.07 Tensioning. Use hydraulic jacks to tension prestressing steel. Use a pressure gauge or load cell for measuring jacking force.

Calibrate measuring devices at least once every 6 months or if they appear to be giving erratic results. Calibrate the jack and gauge as a unit with the cylinder extension in the approximate position that it will be at final jacking force. Keep a certified calibration chart with each gauge.

If a pressure gauge is used, do not gauge loads less than ¼ nor more than ¾ of the total graduated capacity of the gauge, unless calibration data clearly establishes consistent accuracy over a wider range. Use a pressure gauge with an accurate reading dial at least 6 inches (150 millimeters) in diameter.

Measure the force induced in the prestressing steel using calibrated jacking gauges, load cells, or a calibrated dynamometer. Take elongation measurements of the prestressing steel. Determine the required elongation from average load-elongation curves for the prestressing tendons used.

For pre-tensioned members, if there is a discrepancy between the gauge pressure and elongation of more than 5 percent in tendons over 50 feet (15 meters) in length or 7 percent in tendons of 50 feet (15 meters) or less in length determine the source of error before proceeding. Do not allow discrepancies in post-tensioned members to exceed 7 percent.

If the jacking system is equipped with an automatic release valve that closes when the required prestressing force is reached, strand elongation measurements are only required for the first and last tendon tensioned and for at least 10 percent of the remaining tendons.

If a load cell is used, do not use the lower 10 percent of the manufacturer’s rated capacity of the load cell to determine the jacking force.

Do not exceed a temporary tensile stress of 80 percent of the specified minimum ultimate tensile strength of the prestressing steel. Anchor prestressing steel at an initial stress that will result in the retention of a working stress after all losses of not less than those required.

For pre-tensioned members, do not allow the initial release stress after seating, and before other losses, to exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel for stress-relieved strands and 75 percent for low-relaxation strands. For post-tensioned members, do not allow the initial release stress after seating to exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel.

553.08 Pre-tensioned Members. Cast pre-tensioned members to the tolerances shown in Table 553-1.

(a) Prestressing steel. Protect prestressing steel placed in the stressing bed from contamination and corrosion if the stressing bed is to be exposed to weather for more than 36 hours before encasement in concrete.

Free strands of kinks or twists. Accurately hold prestressing steel in position and tension according to Subsection 553.06. Do not allow strands to unwind more than one turn. Keep a record of the jacking force and elongation measurements after the strands are tensioned to 20 percent of final jacking force.

Tension prestressing steel to the required stress. Include in elongation computations strand anchorage slippage, splice slippage, in place horizontal movement of the structural member during prestressing operations, and prestressing steel temperature changes between the time of tensioning and the time when the concrete takes its initial set. Computations must be prepared by a professional engineer.

Maintain the prestress bed forms, strands, and reinforcement bar temperature within 25 °F (14 °C) of the temperature of the concrete to be placed in the forms. Support strands with rollers at points of direction change when strands are tensioned in a draped position. Use free-running rollers with minimal friction. Initially, when strands are tensioned and then pulled into the draped position, tension to no more than the required tension minus the increased tension due to forcing the strand to a draped profile. If the load in a draped strand at the dead end, as determined by elongation measurements, is less than 95 percent of the jack load, tension the strand from both ends of the bed. Make the load, as computed from the sum of elongations produced by jacking at both ends, agree within 5 percent of the jack load.

Within 3 hours before placing concrete, check the tension on the prestressing strands. The method and equipment for checking the loss of prestress will be approved by the CO. If strands are tensioned individually, check each strand for loss of prestress. Retension to the original computed jacking stress for strands that show a loss of prestress in excess of 3 percent. If strands are tensioned in a group, check the entire group for total loss of prestress. Release and retension the entire group if the total prestress shows a loss in excess of 3 percent or if individual strands appears significantly different from the rest of the strands in the group.

(b) Releasing steel. Release the prestress load to the concrete after the concrete has attained its required release compressive strength. Do not expose the concrete to temperatures below freezing for at least 7 days after casting. Cut or release strands such that lateral eccentricity of the prestress force is minimized. Cut off prestressing steel flush with the end of the member, except as noted in the plans.

(c) Debonding strands. Use solid or split plastic sheathing with a minimum thickness of $^{1}/_{32}$ inches (0.8 millimeters) to debond strands. Before placing concrete, use tape to thoroughly seal split and solid sheathing including ends to prevent the migration of concrete mortar along the strand.

553.09 Storing, Transporting, and Erecting. Do not ship prestressed concrete members until concrete cylinder tests, manufactured of the same concrete and cured under the same conditions as the members; indicate that the concrete in each member has attained the minimum required design strength and is at least 7 days old, except decked Bulb-T sections must be at least 10 days old.

Before transporting prestressed concrete members, provide written certification from a professional engineer conforming to the qualifications of Subsection 553.03, that the members were fabricated and visually inspected according to the contract and meet minimum quality requirements.

Store, transport, and erect precast, prestressed girders, slab units, and box units in the upright position with the points of support and directions of the reactions, with respect to the member, approximately the same as when the member is in its final position. Prevent cracking or damage during hoisting, handling, and storing of the precast units. Replace units damaged by improper handling or storing.

553.10 Post-Tensioned Members. Construct post-tensioned members to the tolerances shown in Table 553-1. Construct supporting falsework so that the superstructure is free to lift off the falsework and shorten during post-tensioning. Detail formwork left inside box girders to support the roadway slab to offer minimum resistance to girder shortening due to shrinkage and post-tensioning.

(a) Ducts. Use mortar-tight ducts that are sufficiently-rigid to maintain their shape and alignment during concrete placement and grout installation. Use ducts conforming to the following minimum wall thicknesses:

(1) Metal duct, 2⅝ inch (65 millimeter) diameter	26 gage (0.55 millimeter)
(2) Metal duct, > 2⅝ inches (> 65 millimeter) diameter	24 gage (0.70 millimeter)
(3) High density polyethylene (HPDE)	14 gage (2.0 millimeter)
(4) High density polypropylene (HDPP)	14 gage (2.0 millimeter)
(5) Metal duct with bar tendons preassembled with duct	31 gage (0.25millimeter)

For tendons composed of single prestressing bars, provide ducts with a minimum internal duct diameter of at least ¼ inch (6 millimeters) larger than the outside diameter of the prestressing bar. For multiple wire, bar, or strand tendons, provide a duct nominal internal cross-sectional area of at least two and one-quarter times the net area of the prestressing steel. When tendons are to be placed by the pull through method, provide a duct nominal internal cross-sectional area of at least two and one-half times the net area of the prestressing steel.

Make positive joints between duct sections. Do not make angles at the joints. Use waterproof tape at the joints. Bend ducts without crimping or flattening. Use ferrous metal or polyethylene couplings to connect ducts to anchoring devices.

Protect ducts against crushing, excessive bending, dirt contamination, and corrosive elements during transport, handling, and storing.

In case of duct damage, seal duct with tape, or splice a duct coupler over the damaged section to form a seal that prevents cement paste from entering the duct during the placement of concrete and to prevent leakage during grouting operations.

Provide ducts and anchorage assemblies with inlets for the injection of grout into the duct after prestressing according to the PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide ducts with outlets to allow the escape of air, water, grout, and bleed water according to the PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide inlets and outlets with an inner diameter of at least ¾ inch (19 millimeters) for strand tendons and of at least ½ inch (13 millimeters) for single bar tendons. Extend the length of outlets a sufficient distance out of the concrete member to allow for the proper closing of the outlets.

Place inlets and outlets, at a minimum, in the following locations:

- Anchorage area of the tendon;
- High points of the duct, when the vertical distance between the highest and lowest point is more than 24 inches (600 millimeters);
- Inlet at or near the lowest point of the tendon;
- Outlet at low points of the duct;
- Major changes in the cross-section of the duct, such as couplers and anchorages; and
- Outlet at a distance less than 36 inches (900 millimeter) downstream from high point outlets.

Show inlet and outlet locations on drawings.

Provide positive mechanical shut-off valves for inlets and outlets. Provide inlets and outlets with valves, caps, or other devices capable of withstanding the grouting pressure.

Securely fasten ducts in place to prevent movement. Maintain distances from the forms by stays, blocks, ties, hangers, or other approved supports. Use precast mortar blocks of approved shape and dimensions. Separate layers of ducts by mortar blocks.

Space duct supports according to the PTI, *Guide Specification for Grouting of Post-Tensioned Structures*. Cover the ends of ducts to prevent the entry of water or debris.

Connect inlets and outlets to the duct with metallic or plastic structural fasteners. Do not use components that react with the concrete, cause corrosion of the prestressing steel, or contain water soluble chlorides.

(b) Placing concrete. Where the end of a post-tensioned assembly will not be covered by concrete, recess the anchoring devices so that the ends of the prestressing steel and all parts of the anchoring devices are at least 2 inches (50 millimeters) inside the end surface of the members.

Before placing concrete, demonstrate that ducts are unobstructed. Immediately after concrete placement, blow out the metal conduit with compressed, oil-free air to break-up and remove mortar in the conduit before it hardens. Approximately 24 hours after the concrete placement, flush the metal conduits with water containing lime (calcium oxide) or slaked lime (calcium hydroxide) in the quantity of 0.1 pounds per gallon (12 grams per liter). Blow the water out with compressed, oil-free air.

For post-tensioned members that are to be steam cured, do not install prestressing steel until curing is complete.

(c) Anchorages and distribution. Give at least 10 days notice before installing end fittings or heading wires.

When wires are used, provide an edge distance for any hole for prestressing wire through a stressing washer, unthreaded bearing ring, or plate of at least ¼ inch (6 millimeters) from the root of any threads or the edge of any ring, plate, or washer.

Anchor post-tensioned prestressing steel at the ends by permanent type anchoring devices capable of developing not less than 95 percent of the ultimate tensile strength of the prestressing steel. If the anchoring device is sufficiently large and is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the anchor load to the concrete, the steel distribution plates or assemblies may be omitted.

Enclose loop tendon anchorages in ducts for their entire length.

(d) Prestressing steel. Use a corrosion inhibitor to protect prestressing steel installed in ducts before placing and curing of the concrete. Use a corrosion inhibitor that does not adversely affect the steel, concrete, or bond strength of the steel to concrete.

If prestressing steel is installed in the ducts within 10 days after concrete curing, stressing, and grouting are completed, no corrosion inhibitor is required.

(e) Post-tensioning. Wait at least 10 days after the last concrete has been placed in the member or until tests on concrete cylinders indicate that the concrete has attained the minimum compressive strength. Demonstrate that the prestressing steel is free and unbonded in the duct. Straighten wires if necessary to produce equal stress in all wires, wire groups, or parallel lay tendons that are stressed simultaneously. Remove side forms for girders before post-tensioning.

Record gauge pressures and prestressing steel elongation at all times while tensioning prestressing steel and submit records.

Determine the friction loss in the prestressing process (that is the difference between tension at the jack and minimum tension in the prestressing steel) according to the AASHTO, *Load and Resistance Factor Design (LFRD) Bridge Design Specifications*.

Use suitable shims or other approved devices to attain the specified anchor set loss.

(f) Grouting. Provide Class A, B, C, or D grout as specified and prestressing steel that is free of dirt, loose rust, grease, or other deleterious material. Bond post-tensioned prestressing steel to the concrete by filling the void space between the duct and tendon with grout according to the PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Perform grouting operations using staff with grouting experience on projects of a similar type and magnitude. Perform grouting operations under the immediate supervision of an individual skilled in various aspects of grouting and who is certified by the American Segmental Bridge Institute (ASBI) Grouting Certification program. Furnish the name of the grouting operations supervisor and proof of their ASBI certification and grouting experience before beginning grouting operations.

Make available on-site before beginning grouting operations, the required testing equipment for checking grout workability (flow-cone), temperatures, and other specified tests.

Use grouting equipment capable of continuous operation with little variation of pressure, which also includes a system for recirculating the grout while actual grouting is not in progress. Use grouting equipment capable of maintaining a pressure on completely grouted ducts and fitted with a valve that can be locked off without loss of pressure in the duct.

Provide written certification that ingredients used in the grout meet the ASTM requirements contained in the PTI, *Guide Specification for Grouting of Post-Tensioned Structures*. This includes, but is not limited to, the following:

(1) Cement mill test reports;

(2) Mineral additives test reports;

(3) Chemical admixtures reports; and

(4) Test reports for other ingredients used in the grout.

For prepackaged grouts, provide the manufacturer’s current certified mill test reports for the product.

Do not use compressed air to aid in the pumping of grout.

Provide grout pumps of a positive displacement type, capable of providing a continuous flow of grout, and capable of maintaining an outlet pressure of at least 150 pounds per square inch (1 megapascal) and with a pressure gauge having a full-scale reading of not more than 300 pounds per square inch (20 megapascals).

Grout only when the efflux time of a grout sample immediately after mixing is between 11 and 30 seconds according to ASTM C939.When hot weather conditions may cause quick setting of the grout, cool the grout by approved methods, as necessary, to prevent blockages during pumping operations. When freezing weather conditions are possible during and following placement of grout, protect the grout from damage by freezing according to the PTI, *Guide Specification for Grouting of Post-Tensioned Structures.*

Provide a supply of potable water and standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch (1.7 megapascals) and of sufficient capacity to flush out partially-grouted ducts.

Clean ducts of material that would impair bonding of the grout or interfere with grouting procedures. Blow out each duct with compressed, oil-free air. Check inlets and outlets for their capacity to accept injection of grout by blowing compressed, oil-free air through the system and proving each inlet and outlet in turn.

Pass grout through a screen with ⅛ inch (3 millimeters) maximum clear openings before entering the grout pump. Open grout vents before the start of grouting. Completely fill the duct by injecting grout from the lowest end of the tendon in an uphill direction. Pump grout continuously through the duct and waste at the outlet until no visible slugs of water or air are ejected, and the efflux time of ejected grout is between 11 and 30 seconds. Maintain a continuous, one-way flow of grout within a grouting stage.

Close outlets in a similar manner one after the other in the direction of the flow. For outlets placed a short distance downstream from a high point, close that outlet before its associated high point outlet. Increase the grouting pressure at the injection end to at least 100 pounds per square inch (0.7 megapascals) and hold for at least 10 seconds. Do not remove or open valves and caps until the grout has set.

Abrasive blast clean the concrete surface of recessed anchorage assemblies. Fill anchor recesses with concrete conforming to the requirements for the structure and finish flush.

Remove ends of vents 1 inch (25 millimeters) below the roadway surface after grouting has been completed. Permanently seal recess areas.

Do not release the falsework under the bottom slab supporting the superstructure until at least 48 hours after grouting of the post-tension prestressing steel or until the grout strength is obtained.

Table 553-1
Prestressed Concrete Member Tolerances

Description	Tolerance
Precast Girders With Cast-In-Place Deck[(1)]	
Length	±¼ in/25 ft, ±1 in max. (±6 mm/10 m, ±25 mm max.)
Width (overall)	+⅜ in, -¼ in (+10 mm, -6 mm)
Depth (overall)	+½ in, -¼ in (+13 mm, -6 mm)
Depth (flanges)	-¼ in (-6 mm)
Width (web)	+⅜ in, -¼ in (+10 mm, -5 mm)
Sweep [(2)]	⅛ in/10 ft (3 mm/3 m)
Variation from end squareness or skew	±$^{3}/_{16}$ in/ft, ±1 in max. (±5 mm/10 m, ±25 mm max.)
Camber variation from design camber	±⅛ in/10 ft (±3 mm/3 m) ±½ in, max. ≤ 80 ft length (±13 mm, max. ≤ 25 m length) ±1 in, max. > 80 ft length (±25 mm, max. > 25 m length)
Position of strands: Individual Bundled Position from design location of deflection points for deflected strands	 ±¼ in (±6 mm) ±½ in (±13 mm) ±20 in (±500 mm)
Position of plates other than bearing plates	±1 in (±25 mm)
Position of bearing plates	±⅝ in (±15 mm)
Tipping and flushness of plates	±¼ in (±6 mm)
Tipping and flushness of bearing plates	±⅛ in (±5 mm)
Position of inserts for structural connections	±½ in (±13 mm)
Position of handling devices: Parallel to length Transverse to length	 ±6 in (±150 mm) ±1 in (±25 mm)
Position of stirrups: Longitudinal spacing Projection above top	 ±2 in (±50 mm) ±¾ in (±19 mm)
Local smoothness [(3)]	±¼ in in 10 ft (±6 mm in 3 m) any surface

Table 553-1 (continued)
Prestressed Concrete Member Tolerances

Description	Tolerance
Precast Girders Used In Multi-Beam Decks (4)	
Length	±¾ in (±19 mm)
Width (overall)	±¼ in (±6 mm)
Depth (overall)	±¼ in (±6 mm)
Depth (top flange)	±½ in (±13 mm)
Depth (bottom flange)	+½ in, -⅛ in (+15 mm, 5 mm))
Width (web)	±⅜ in (±10 mm)
Sweep (5)	
Up to 40 ft (12 m) member length	±¼ in (±6 mm)
40 to 60 ft (12 to 18 m) member length	±⅜ in (±10 mm)
Greater than 60 ft (18 m) member length	±½ in (±13 mm)
Variation from end squareness or skew Horizontal Vertical	±⅛ in/ft (±10 mm/m) ±½ in max. (±13 mm max.) ±½ in (±13 mm)
Camber variation from design camber	±⅛ in/10 ft, ±½ in max. (±3 mm/3 m, ±13 mm max.)
Differential camber between adjacent members of the same design	¼ in/10 ft, ¾ in max. (±6 mm/3 m, ±20 mm max.)
Position of Strands: Individual Bundled Position from design location of deflection points for deflected strands	 ±¼ in (±6 mm) ±¼ in (±6 mm) ±20 in (±500 mm)
Position of plates other than bearing plates	±1 in (±25 mm)
Tipping and flushness of plates	±¼ in (±6 mm)
Position of inserts for structural connections	±½ in (±15 mm)
Position of handling devices: Parallel to length Transverse to length	 ±6 in (±150 mm) ±1 in (±25 mm)

Table 553-1 (continued)
Prestressed Concrete Member Tolerances

Description	Tolerance
Precast Girders Used In Multi-Beam Decks	
Position of stirrups: Longitudinal spacing Projection above top	 ±1 in (±25 mm) +¼ in, -¾ in (+6 mm, -20 mm)
Tipping of beam seat bearing area	±⅛ in (±5 mm)
Position of dowel tubes	±⅝ in (±15 mm)
Position of tie rod tubes: Parallel to length Vertical	 ±½ in (±13 mm) ±⅜ in (±10 mm)
Position of slab void: End of void to center of tie hole Adjacent to end block	 ±½ in (±13 mm) ±1 in (±25 mm)
Local smoothness (6)	±¼ in in 10 ft (±6 mm in 3 m) any surface
Post-Tension Members	
Position of post tensioning ducts	±¼ in (±5 mm)
Position of tendon anchorage bearing plates	±¼ in (±5 mm)

(1) AASHTO I Beams and Bulb-T Girders.
(2) Variation from straight line parallel to centerline of member.
(3) Does not apply to top surface left rough to receive a topping or to visually concealed surfaces.
(4) Box beams, slabs, decked bulb tee, and multi-stem girders.
(5) Variation from straight line parallel to centerline of member.
(6) Does not apply to top surface left rough to receive a topping or to visually-concealed surfaces.

553.11 Painting Steel. Use a wire brush or abrasive blast to remove dirt and residue not firmly bonded to the metal or concrete surfaces. Clean and paint the exposed ends of the prestress steel, post-tension anchor head assemblies, and a 1-inch (25-millimeter) strip of adjoining concrete.

Mix zinc-rich paint conforming to FSS TT-P-641. Work the paint into voids in the prestressing tendons. Apply one thick coat to surfaces that will be covered with concrete. Apply two coats to surfaces not covered with concrete.

553.12 Acceptance. See Tables 552-9 and 553-2 for sampling, testing, and acceptance requirements.

Prestressing steel, reinforcing steel, anchor devices, elastomeric bearings, and material for concrete and grout will be evaluated under Subsection 106.03. Furnish production certifications with each shipment of hydraulic cement, prestressing steel, and reinforcing steel.

Grouting will be evaluated under Subsections 106.02 and 106.04. Sampling and testing requirements will be according to the PTI, *Guide Specification for Grouting of Post-Tensioned Structures.*

Concrete for precast, prestressed concrete members will be evaluated under Subsections 106.02, 106.03, and 106.04.

Concrete for post-tensioned, cast-in-place concrete members will be evaluated under Section 552.

Construction of precast, prestressed concrete members and post-tensioned, cast-in-place concrete members will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Falsework and forms will be evaluated under Section 562.

Measurement

553.13 Measure the Section 553 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure reinforcing steel and concrete for precast, prestressed concrete structural members.

Measure the concrete for post-tensioned, cast-in-place concrete structures under Section 552.

Measure the reinforcing steel for post-tensioned, cast-in-place concrete structures under Section 554.

Measure prestressed piling under Section 551.

Payment

553.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 553 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 553-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Prestressed concrete	Measured and tested for conformance (106.04)	Compressive strength	–	AASHTO T 23 & T 22	1 per 30 yd^3 (25 m^3)(2)	Discharge stream at point of placing(1)	Yes	Upon completing tests	–
Grout	"	–	–	PTI, *Guide Specification for Grouting of Post-Tensioned Structures*	Each mixture	Each source	No	"	–

(1) Sample according to AASHTO R 60, except composite samples are not required.

(2) In addition to the test cylinders required to determine 28-day strength, cast two release cylinders for each concrete member. Cure the release-strength cylinders with the concrete member that they represent.

Section 554. — REINFORCING STEEL

Description

554.01 This work consists of furnishing and placing reinforcing steel.

Material

554.02 Conform to the following Subsection:

Reinforcing steel	709.01

Construction Requirements

554.03 Order Lists. On reinforcing steel order lists, use the same respective bar marks for labeling as shown in the plans. Submit order lists and bending diagrams for approval. Approval does not relieve the Contractor of responsibility for the accuracy of the lists and diagrams. Do not order material until the lists and diagrams are accepted.

Do not fabricate vertical reinforcement in columns, walls, piers, and shafts until footing elevations are established in the field.

554.04 Identification. Ship bar reinforcement in standard bundles, tagged and marked according to CRSI, *Manual of Standard Practice*.

554.05 Bending. Fabricate reinforcing bars according to ACI SP-66, *ACI Detailing Manual*. Cold bend reinforcing bars that require bending. Limit the overall height or drop bending tolerance of deck truss bars to plus 0 inch (0 millimeter) or minus ¼ inch (6 millimeters). Do not bend bars partially embedded in concrete, except as shown in the plans or otherwise permitted.

Provide standard hooks conforming to ACI SP-66.

554.06 Protection of Material. Store reinforcing steel above the ground on platforms, skids, or other supports. Protect from physical damage, rust, and other surface deterioration.

Use reinforcing steel only when the surface is clean and the minimum dimensions, cross-sectional area, and tensile properties conform to the physical requirements for the size and grade of steel specified.

Do not use reinforcing steel that is cracked, laminated, or is covered with dirt, rust, loose scale, paint, grease, oil, or other deleterious material.

554.07 Epoxy-Coated Reinforcing Steel. Support coated bars on padded contact areas. Pad bundled bands. Lift with a strong back, multiple supports, or a platform bridge. Prevent bar-to-bar abrasion. Do not drop or drag bundles.

Before placement, inspect bars for coating damage. Replace and do not use bars with a total damaged area in any 12-inch (300-millimeter) length that exceeds 5 percent of the surface area of that length of the bar.

Clean other damaged coatings by removing surface contaminants and the damaged coating. Roughen the area around the damage and remove rust by blast cleaning or power tool cleaning. Use a prequalified ASTM A775 patching/repair material to patch defects in the coating that are discernible to the unaided eye. Overlap the patching material onto the original coating for 2 inches (50 millimeters) or as recommended by the manufacturer. Provide a minimum 8 mil (200-micrometer) dry film thickness on the patched areas.

Take necessary steps to minimize damage to the coating of installed bars. Clean and patch damage to coatings noted after installation as described above. Promptly treat the bar according to the resin manufacturer's recommendations and before detrimental oxidation occurs.

Coat mechanical splices after splice installation according to ASTM A775 for patching damaged epoxy coatings.

554.08 Placing and Fastening. Place, fasten, and support the bars according to the CRSI, *Manual of Standard Practice*. Coat chairs, tie wires, and other devices used to support, position, or fasten epoxy-coated reinforcement with a dielectric material.

Use precast concrete blocks or metal supports. Attach concrete block supports to the supported bar with wire cast in the center of each block. Use Class 1 (plastic protected) or Class 2, Type B (stainless steel protected) metal supports in contact with exposed concrete surfaces. Use stainless steel conforming to ASTM A493, Type 430.

Space slab bar supports no more than 48 inches (1200 millimeters) apart transversely or longitudinally. Do not use bar supports either directly or indirectly to support runways for concrete buggies or other similar construction loads. Replace damaged supports.

Place bars within 1½ inches (38 millimeters) of the plan location. Do not cumulate spacing variations. Do not allow the average of any two adjacent spaces to exceed the required spacing. Place reinforcing steel in deck slabs within ¼ inch (6 millimeters) of the vertical plan location. Using a template, check the clear cover over deck reinforcing steel before placing deck concrete.

Provide 2 inches (50 millimeters) clear cover for reinforcement. The tolerance on minimum concrete cover is minus ⅜ inch (10 millimeters). For concrete surfaces cast against the ground provide a minimum 3 inches (75 millimeters) of clear cover over reinforcement.

Tie reinforcing at intersections around the perimeter of each mat and at not more than 24-inch (600-millimeter) centers or at every intersection, whichever is greater. Tie bridge deck reinforcing bars at not more than 12 inch (300 millimeter) or every intersection, whichever is greater.

Tie bundle bars together at intervals not exceeding 6 feet (1.8 meters). Do not bundle bars unless the location and splice details are specified.

Do not place concrete in members until the reinforcing steel placement is approved.

554.09 Splices. Splicing, except as shown in the plans, is not permitted without approval. Provide lap lengths shown in the plans. Splice reinforcing bars only where shown in the plans or accepted drawings.

Make lapped splices by placing the reinforcing bars in contact and wiring them together so as to maintain the alignment and position of the bars.

If welding of reinforcing steel is permitted, use welders with current certifications and make the welds conform to AWS, *Structural Welding Code - Reinforcing Steel, D 1.4 (D1.4M)*. Do not weld reinforcing steel if the chemical composition of the steel exceeds the percentages in Table 554-1.

Table 554-1
Reinforcing Steel Components

Chemical Composition	Percent
Carbon (C)	0.30
Manganese (MA)	1.50
Carbon Equivalent (C.E.)	0.55

Mechanical couplers may be used instead of welding if approved. Use couplers with a strength that is at least 125 percent of the required yield strength of the reinforcing steel. Do not exceed 0.01 inches (0.25 millimeters) total slip of the reinforcing bar within the splice sleeve when loading in tension to 30.0 kips per square inch (207 megapascals) and relaxing to 3.0 kips per square inch (20 megapascals) for bar sizes up to No. 14 (No. 43) as measured between gage points clear of the splice sleeve.

If welded wire fabric is shipped in rolls, straighten into flat sheets before placing. Splice sheets of mesh or bar mat reinforcement by overlapping not less than 1-mesh width plus 2 inches (50 millimeters). Securely fasten at the ends and edges.

554.10 Acceptance. Reinforcing steel and epoxy coating material will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each shipment of reinforcing steel.

Placement of reinforcing steel will be evaluated under Subsections 106.02 and 106.04.

Measurement

554.11 Measure the Section 554 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure reinforcing steel excluding laps added for the Contractor's convenience.

Payment

554.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 554 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 555. — STEEL STRUCTURES

Description

555.01 This work consists of constructing steel structures and the steel structure portions of composite structures. This work also includes furnishing, fabricating, and erecting structural steel and incidental metal construction.

Material

555.02 Conform to the following Sections and Subsections:

Bearing devices	564
Bolts and nuts	717.01(d)
Castings	717.04
Galvanized coatings	717.07
High-strength bolts, nuts, and washers	717.01(e)
Painting	563
Pins and rollers	717.03
Preformed polychloroprene elastomeric joint seal for bridges	712.01(g)
Sheet lead	717.08
Steel forgings	717.02
Steel grid floors	717.09
Steel pipe	717.06
Structural steel	717.01
Temporary works	562
Welded stud shear connectors	717.05

Construction Requirements

555.03 Drawings and Diagrams. Submit drawings according to Subsection 104.03.

(a) Fabrication drawings. Show complete detailed dimensions and sizes of component parts of the structure and details of miscellaneous parts.

Show the direction of plate rolling where specific orientation of plates is required. Show plate girder flanges and webs cut from plates so the long dimension of the girder parallels the rolling direction.

Identify the type and grade of each piece that is to be made of steel other than AASHTO M 270, Grade 36 (250) steel.

Show assembly marks that are cross-referenced to the original pieces of mill steel and their certified mill test reports.

Shop-welded splice locations shown on the drawings are subject to approval. Locate shop-welded splices to avoid points of maximum tensile or fatigue stress. Locate splices in webs at least 12 inches (300 millimeters) from shop splices, flange butt joints, or stiffeners. Additional nondestructive tests may be required on shop-welded splices.

(b) Erection drawings. Fully illustrate the proposed method of erection. Show details of falsework bents, bracing, guys, dead-men, lifting devices, and bridge member attachments. Show the erection sequence, crane and barge locations, crane capacities, lifting point locations, and bridge member masses. Show complete details for anticipated phases and erection conditions. If required by the CO during drawing review, provide calculations showing that allowable stresses are not exceeded and that member capacities and final geometry are correct. See Section 562 for additional requirements.

(c) Camber diagram. Show the camber at each truss or arch rib panel point, at field splice locations, and at the specified span length fractions of continuous beams and girders or rigid frames. Show calculated cambers to be used in preassembly of the structure as required in Subsection 555.14.

(d) Transportation drawings. Show support points, tie-downs, temporary stiffening trusses or beams, and other details needed to support and brace the member. Provide calculation sheets showing self-weight plus dynamic load allowance stresses induced by the loading and transportation procedure. Use dynamic load allowance stresses of at least 100 percent of the dead load stress. Do not allow fatigue stresses to exceed the constant-amplitude fatigue threshold for the appropriate categories. Verify computed girder stresses satisfy the AASHTO, *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*.

Ship and store members in the same orientation as the completed structure unless otherwise approved by the CO.

555.04 Fabrication Notice. Give written notice at least 21 days before beginning fabrication work. Do not manufacture material before notification and drawings are approved.

555.05 Inspection. Structural steel may be inspected at the fabrication site according to Subsection 106.06.

Ultrasonically inspect girder flanges before fabrication according to ASTM A578 and the following:

(a) Inspect after flanges are stripped from the master plate;

(b) Use supplementary requirement S2.1 for acceptance standards; and

(c) Inspect flanges in the plant or warehouse where the flanges are stripped.

Furnish copies of mill orders at the time orders are placed with the manufacturer. Furnish certified mill test reports and production certifications before the start of fabrication using material covered by these reports. Furnish a production certification from the manufacturer according to Subsection 106.03.

Include on certified mill test reports the chemical analyses and physical test results for each heat of steel used in the work and for steels with specified impact values, include the results of Charpy V-notch impact tests. Confirm on the test report that the material was so produced when fine-grain practice is specified.

Furnish production certifications instead of mill test reports for material that is not normally supplied with mill test reports and for items such as fills, minor gusset plates, and similar material when quantities are small and the material is taken from stock.

555.06 Storing Material. Store structural material above the ground on platforms, skids, or other supports. Keep material without dirt, grease, and other foreign matter. Protection from corrosion and stray electrical currents.

555.07 Fabrication. Fabricate structural steel in a fabricating plant that is certified under the AISC, *Quality Certification Program*. Furnish and fabricate fracture critical elements according to AASHTO, *LRFD Bridge Design Specifications* and Clause 12 of the AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)*.

Remove mill scale and foreign material from exterior surfaces of exterior girders of unpainted weathering steel by blast cleaning according to SSPC-SP6, *Commercial Blast Cleaning*. Then dry the surface and apply at least three uniform applications of water mist at 24 hour intervals to ensure uniform weathering.

Do not heat curved steel girders.

Do not drill, cut, or weld portions of structural members unless shown in the plans or approved in writing.

(a) Steel identification. Use a system of assembly-marking of individual pieces and cutting instructions (generally by cross referencing of the assembly-marks shown on the drawings with the corresponding item covered on the mill purchase order). Provide information to the shop that maintains the identity of the original piece.

Identify material furnished from stock by heat number and mill test report.

During fabrication and before assembling members, show the specification of each piece of steel (other than Grade 36 (250) steel). Mark steel using steel die stamping or firmly attaching a substantial tag to pieces of steel which will be subject to fabricating operations which might obliterate paint marking before assembling into members. These fabrication operations include blast cleaning, galvanizing, heating for forming, or painting.

Use low-stress type steel die stamps. Avoid impressions near edges of tensile-stressed plate members. Do not use die stamps on fracture-critical members.

Furnish an affidavit certifying the identification of steel has been maintained throughout the fabrication operation.

(b) Plates.

(1) Rolling direction. Cut and fabricate steel plates for main members and splice plates for flanges and main tension members, so that the primary direction of rolling is parallel to the direction of the principal tensile and compressive stresses.

(2) Plate cut edges.

(a) Edge planing. Remove sheared edges on plates thicker than $^{5}/_{8}$ inches (15 millimeters) to a depth of ¼ inch (6 millimeters) beyond the original sheared edge or beyond re-entrant cuts produced by shearing. Fillet re-entrant cuts before cutting.

(1) Oxygen cutting. Perform oxygen cutting according to AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)*.

(2) Visual inspection and repair of plate cut edges. Visually inspect and repair plate cut edges. Conform to AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)*.

(b) Flange plates. Furnish flange plates with either oxygen-cut edges that have ground corners chamfered at least $^{1}/_{16}$ inch (1.6 millimeters) or furnish universal mill plates.

(c) Web plates. Use oxygen cutting to provide the prescribed camber in web plates of built-up beams and girders, box girders, and box arches. Cut sufficient extra camber into the webs to provide for camber losses due to welding and cutting.

(d) Truss members. Prepare longitudinal edges of plates in welded sections of truss web and chord members by oxygen cutting. Use grinding to chamfer the edges of the corners of plates at least $^{1}/_{16}$ inch (1.6 millimeters) when plates are not joined by welding.

(e) Stiffeners and connection plates. Sheared edges may be used on plate thicknesses up to ¾ inches (19 millimeters) for stiffeners and connection plates welded transverse to girder webs and flanges. Universal mill plate may be used for plate thicknesses up to 1 inch (25 millimeters). Furnish other stiffeners and connection plates with oxygen-cut edges.

(f) Lateral gusset plates. Bolted lateral gusset plates may be furnished with sheared edges provided the thickness is less than or equal to ¾ inches (19 millimeters). Oxygen cut, parallel to lines of stress, gusset plates and other connections welded parallel to lines of stress in tension members where the plate thickness exceeds ⅜ inches (10 millimeters).

(g) Splice plates and gusset plates. Furnish with oxygen-cut edges.

(h) Bent plates. Furnish un-welded, load-carrying, rolled steel plates.

Bend plates at right angles to the direction of rolling, except cold-bent ribs for orthotropic-deck bridges may be bent in the direction of rolling.

Before bending, round the plate corners to a radius of $^{1}/_{16}$ inch (1.6 millimeters) throughout the portion of the plate where the bending occurs.

(1) Cold bending. Do not cold-bend fracture-critical steels and fracture-critical members.

For other steels and members, cold bend according to Table 555-1 so that no plate cracking occurs. Allow for springback of Grades 100 (690) and 100W (690W) steels equal to about three times that for Grade 36 (250) steel. Use a lower die span of at least sixteen times the plate thickness for break press forming.

(2) Hot bending. If a radius shorter than the minimum specified for cold bending is required; hot bend the plates at a temperature less than 1,200 °F (650 °C), except for Grades 70W (485W), 100 (690) and 100W (690W). When steel plates are heated to temperatures greater than 1,100 °F (595 °C) for Grade 100 (690) and Grade 100W (690W) or greater than 1,050 °F (565 °C) for Grade 70W (485W); re-quench and temper according to the producing mill's standard practice and test to verify restoration of specified properties. Do not heat Grade HPS 70W (HPS 485W) to a temperature greater than 1,100 °F (595 °C). Re-quenching and tempering is not required for Grade HPS 70W (HPS 485W) steel heated to this limit.

Table 555-1
Minimum Cold-Bending Radii[(1)]

Grade, **kips per square inch (megapascals)**	**Thickness, (*t*)**			
	$t \leq$ ¾ inch (t ≤ 20 mm)	¾ inch < $t \leq$ 1 inch (20 mm < $t \leq$ 25 mm)	1 inch < $t \leq$ 2 inches (25 mm < $t \leq$ 50 mm)	$t >$ 2 inches ($t >$ 50 mm)
36 (250)	1.5*t*	1.5*t*	1.5*t*	2.0*t*
50 (345), 50S (345S), 50W (345W), or HPS 50W (HPS 345W)	1.5*t*	1.5*t*	2.0*t*	2.5*t*
HPS 70W (HPS 485W)	1.5*t*	1.5*t*	2.5*t*	3.0*t*
100 (690)	1.75*t*	2.25*t*	4.5*t*	5.5*t*
100W (690W)	1.75*t*	2.25*t*	4.5*t*	5.5*t*

(1) Values shown are for the concave face of the metal bent perpendicular to the direction of final rolling. If the bend is parallel to the direction of final rolling, multiply the minimum radii shown by 1.5 (that is 1.5*t* perpendicular to rolling equates to 2.25*t* parallel to rolling).

(c) Stiffener fit. Fabricate (mill, grind, or weld) girder end bearing stiffeners and concentrated load bearing stiffeners to provide full bearing on the flanges to which the load is transmitted or received. Fabricate intermediate stiffeners to provide a tight fit against the compression flange.

(d) Abutting joints. Mill or saw cut abutting joints in truss and column compression members to obtain a square joint and uniform bearing. Other joints not required to be faced may have openings up to ⅜ inch (10 millimeters).

(e) Bearing surface facing. Finish bearing surfaces according to Table 555-2 and ASME, B46.1 *Surface Roughness, Waviness and Lay, Part I.*

Table 555-2
ASME Surface Roughness Values

Bearing Surface	**Surface Roughness Value µin (µm)**
Steel slabs	2,000 (50)
Heavy plates in contact in shoes to be welded	1,000 (25)
Milled ends of compression members, milled or ground ends of stiffeners and fillers	500 (13)
Bridge rollers and rockers	250 (6)
Pins and pin holes	125 (3)
Sliding bearings	125 (3)

Machine sliding bearings with a surface roughness greater than 75 micro-inches (2 micrometers) so the lay of the cut is parallel to the direction of movement.

Fabricate bearing parts to provide uniform even contact with the adjacent bearing surface. Limit the maximum gap between bearing surfaces to 0.04 inches (1 millimeter). Machine the base plate sliding surfaces if the plane and true base and sole plates exceed the surface roughness value of Table 555-2.

Do not machine surfaces of fabricated assemblies until heat treatment and fabrication on the assembly is complete.

(f) Straightening material. Straighten plates, angles, other shapes, and built-up members using methods that do not fracture or damage the metal when approved by the CO.

Use mechanical means or a limited amount of localized heat when approved by the CO. Do not exceed the temperatures shown in Table 555-3 and control the heat application with temperature-indicating crayons, liquids, or bimetal thermometers. Remove external forces from the material to be straightened, except for the mechanical stress designed to be used in conjunction with the heat.

Table 555-3
Maximum Straightening Temperatures

Material to be Straightened	Maximum Temperature
Grade HPS 1100W (Grade HPS 690W)	1100 °F (595 °C)
Grade 100W (Grade 690W)	1100 °F (590 °C)
Other Steels	1200 °F (650 °C)

555.08 Annealing and Stress Relieving. Normalize and anneal (full annealing) according to ASTM A941. Maintain uniform temperatures throughout the furnace during the heating and cooling so the temperature at no two points on the member differs by more than 100 °F (55 °C).

Record each furnace charge, identify the pieces in the charge, and show the temperatures and schedule used. Provide proper instruments including recording pyrometers for determining member temperatures. Provide records of the treatment operation for approval.

Do not anneal or normalize HPS 100W (HPS 690W) or HPS 70W (HPS 485W) steel members without approval. See Table 555-3 for the maximum stress relieving holding temperature for these grades.

Stress relieve members (such as bridge shoes, pedestals, or other parts that are built-up by welding sections of plate together) according to Subsection 4.4 of AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)*.

555.09 Bolt Holes. Punch or drill bolt holes. If required below, either subpunch or subdrill holes $^{3}/_{16}$ inch (5 millimeters) smaller than the nominal bolt diameter and after assembling ream or drill full size.

(a) Punched holes. Unless subpunching and reaming is required by Subsection 555.09(h); punch material forming parts of a member with no more than 5 metal thicknesses if the material thickness is no greater than:

(1) ¾ inch (19 millimeters) for structural steel;

(2) ⅝ inch (15 millimeters) for high-strength steel; or

(3) ½ inch (13 millimeters) for quenched and tempered alloy steel.

Punch holes 1/16 inch (1.6 millimeters) larger than the nominal bolt diameter. Ream holes that require enlarging to admit bolts. Produce clean cut holes without torn or ragged edges.

(b) Reamed or drilled holes. Subdrill and ream or drill holes full-size where there are more than five thicknesses or where the main material is thicker than Subsection 555.09(a)(1) thru (3).

Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling. Where practical, use twist drills, twist reamers, or roto-broach cutters directed by mechanical means. Ream or drill cylindrical holes 1/16 inch (1.6 millimeters) larger than the nominal bolt diameter that are perpendicular to the member. Remove burrs on the outside surfaces.

(c) Accuracy of holes. Drilled or reamed holes may be up to 1/32 inch (0.8 millimeter) larger than the true decimal equivalent of the nominal diameter of the drill or reamer. Punched holes may be slightly conical. Slotted holes produced by flame-cutting or a combination of drilling, or punching and flame cutting may be up to 1/32 inch (0.8 millimeter) larger than the nominal width. Grind flame cut surfaces smooth to a maximum surface roughness of 1000 micro-inches (25 micrometers).

(d) Accuracy of hole group before reaming. Punch, subpunch, or subdrill holes to allow a cylindrical pin 3/16 inch (5 millimeters) smaller in diameter than the nominal size of the punched hole can be inserted in holes after assembling (before reaming). In addition, produce at least 75 percent of the contiguous holes in the same plane such that a cylindrical pin ⅛ inch (3 millimeters) smaller in diameter than the nominal size of the punched hole can be inserted perpendicular to the face of the member without drifting.

(e) Accuracy of hole group after reaming. Use dimensioned steel templates with hardened steel bushings in the holes. Use connection centerlines when locating templates from the milled or scribed ends of members. Produce at least 85 percent of the holes in a contiguous group of holes with a maximum offset of 1/32 inch (0.8 millimeter) between adjacent thicknesses of metal after reaming or drilling.

(f) Numerically-controlled drilled field connections. Drill or punch full-sized bolt holes in unassembled pieces and connections using numerically-controlled drilling or punching equipment.

(g) Holes for ribbed bolts, turned bolts, or other approved bearing-type bolts. Provide finished holes with a driving fit.

(h) Preparation of field connections. Drill full size holes through all thicknesses of material assembled in proper position for field connections and field splices. Do not punch full-size holes in longitudinal main load-carrying members, transverse floor beams, or components designated as fracture critical members. Other options include the following:

(1) Main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frame connections and splice holes. Subpunch or subdrill and ream while assembled, or drill full size to a steel template.

(2) Rolled beam stringers continuous over floor beams or cross frames. Drill full-size holes for field splices unassembled to a steel template.

(3) Floor beam and stringer field end connection holes. Subpunch and ream while assembled, or drill full size to a steel template.

(4) Cross frames, lateral bracing components, and the corresponding holes in connection plates between girders and cross frames or lateral components. Punch full-size holes.

Locate, position, and firmly bolt the template in place when reaming or drilling full size field-connection holes through a steel template. Use duplicates of templates used for reaming matching members or the opposite faces of a single member. Locate templates used for connections on like parts or members so that the parts or members are duplicates and require no match-marking.

555.10 Pins and Rollers.

(a) Fabricating pins and rollers. Fabricate straight and smooth pins and rollers without flaws.

Forge and anneal pins and rollers or use cold-finished carbon steel shafting for diameters less than 9 inches (230 millimeters). Slowly cool forged pins to a temperature below the critical range to prevent damage from rapid cooling. Bore a hole in the pin not less than 2 inches (50 millimeters) in diameter full-length along the pin axis before annealing.

(b) Boring pin holes. Do not exceed the pin diameter by more than $^{1}\!/_{50}$ inch (0.50 millimeters) for pins 5 inches (130 millimeters) or less in diameter or exceed by more than $^{1}\!/_{32}$ inch (0.8 millimeter) for larger pins when boring pin holes. Bore pin holes smooth, straight, at right angles with the axis of the member, and parallel with each other. Produce the final surface using a finishing cut.

Produce a maximum variation in the distance outside-to-outside of end holes in tension members and inside-to-inside of end holes in compression members of $^{1}\!/_{32}$ inch (0.8 millimeter) from that specified. Bore pin holes in built-up members after the member is assembled.

(c) Threads for bolts and pins. Conform to the ASME, B1.1 *Unified Inch Screw Threads (UN and UNR Thread Form),* Class 2A for external threads and Class 2B for internal threads (ASME, B1.13M *Metric Screw Threads: M Profile*, tolerance Class 6G for external threads and Class 6H for internal threads). Provide six threads per inch (25 millimeters) for pin ends with a diameter of 1⅜ inches (35 millimeters) or greater.

555.11 Eyebars. Provide eyebars that are straight and without twists. Limit the inclination of bars to the plane of the truss to a 0.5 percent slope.

Locate pin holes on the centerline of the eyebar. Securely clamp eyebars that are to be placed side-by-side in the structure in the order they are to be placed on the pin. Bore the pin holes to the finished diameter from both ends or flame cut the pin holes at least 2 inches (50 millimeters) smaller than the finished pin diameter.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically-operated torches abreast of each other guided by a substantial template to prevent distortion of the plates.

Use low-stress type steel die stamps to match-mark eyebars for shipment and erection. Locate stamps on the visible edge each member when the bars are nested in place on the structure.

555.12 Assembly-Bolting. Clean metal contact surfaces. Assemble, securely pin, and draw together member parts. Drill, ream, and bolt the assembly. If necessary, take assembly apart to remove burrs and shavings produced by the operation.

Assemble the members without twists, bends, and other deformation. Drift only enough to bring the parts into position without enlarging holes or distorting metal.

555.13 Welded Connections. Conform to AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)*. Install shear connector studs according to Chapter 7. Perform preproduction testing according to Subsection 7.7.1 and inspect installed studs according to Subsection 7.8.

555.14 Preassembly of Field Connections. Submit method and details of preassembly for approval.

Preassemble field connections of truss, arch, continuous beam, plate girder, bent, tower, and rigid frame main members. Use preassembly methods and details consistent with approved erection procedures and camber diagrams.

Assemble girders and beams in their cambered (no load) condition. When members are assembled with webs vertical, support the members at intervals of 20 feet (6 meters), or two-tenths of the span length, whichever is less. When the webs are horizontal, support intervals may be increased provided there is no noticeable deflection between points of support.

Assemble trusses in full dead-load position unless the design of the structure provides for secondary stresses created by the fully cambered assembly. Start assembly from a location in the structure and proceed in one or both directions. Support trusses at each panel point. Preassemble at least three contiguous panels. For successive assemblies, include at least one section or panel of the previous assembly plus two or more sections or panels added at the advancing end. For structures longer than 150 feet (45 meters), make each assembly at least 150 feet (45 meters) long.

Verify the geometry of the completed structure or unit. Verify or prepare field splices.

(a) Bolted connections. Where applicable, assemble major components with milled ends of compression members in full bearing. While assembled, ream subsized holes to the specified size.

(b) Check assembly/numerically-controlled drilling. Make a check assembly for each major structural type of each project based on proposed order of erection, joints in bearings, special complex points, or similar considerations. Assemble at least three contiguous shop sections. For trusses, assemble members in at least three contiguous panels, but not less than the number of panels associated with three contiguous chord lengths (such as the length between field splices). Other shop assemblies are not required.

Obtain approval of each assembly before reaming holes or dismantling the assembly. Inaccurate camber, alignment, hole alignment, milled joint fit, or other problems may require additional check assemblies.

(c) Field-welded connections. Do not field weld connections unless specifically shown on the drawings. Verify the fit of members (including the proper space between abutting flanges) with the segment preassembled.

(d) Match marking. Match mark connecting parts preassembled in the shop to ensure proper fit in the field. Provide a diagram showing match-marks.

555.15 Connections Using Unfinished, Turned, or Ribbed Bolts. Use bolts conforming to ASTM A307, Grade A with single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope more than 1:20 with respect to a plane normal to the bolt axis.

(a) Turned bolts. Furnish hex headed bolts of the nominal size specified with a body surface ANSI roughness less than 125 micro-inches (3 micrometers). Ream holes to provide for a light driving fit. Keep bolt threads outside of the holes. Provide a washer under the hexagonal nut.

(b) Ribbed bolts. Furnish round headed bolts conforming to ASME, B18.5 *Round Head Bolts (Inch Series)* (ASME, B18.5.2.2M *Bolts, Metric Round Head Short Square Neck*) with continuous longitudinal ribs. Provide a body diameter measured on a circle through the points of the ribs $^{5}\!/_{64}$ inch (2 millimeters) greater than the nominal diameter specified for the bolts. Furnish hexagonal nuts that are either recessed or have a washer of suitable thickness.

Ream holes to provide for a driving fit. Ream the hole and provide an oversized replacement bolt if the ribs compress or deform allowing the bolt to twist before drawing tight.

555.16 Connections Using High-Strength Bolts.

(a) Bolted parts. Use only steel material within the grip of the bolt with no compressible material (such as gaskets or insulation). Fabricate steel parts to fit solidly together after bolts are stressed. Remove burrs that prevent solid seating. Limit the slope between the bolted surface and the plane normal to the bolt axis to 1:20.

(b) Surface conditions. Clean dirt, foreign material, and scale (except tight mill scale) from joint surfaces at the time of assembly. Remove paint (including inadvertent overspray) from areas within the bolt pattern. In non-coated joints, exclude or remove paint closer than 1 inch (25 millimeters) or one bolt diameter, whichever is larger, from the edge of holes.

(c) Installation. Use fasteners of the same lot number for each connection. Protect fasteners from dirt and moisture. Only remove the fasteners from protected storage that are to be installed and tensioned during a work shift. Return unused fasteners to protected storage at the end of the shift. Do not remove as-delivered lubricant from fasteners. Discard and replace fasteners for slip-critical connections that accumulate rust or dirt before installing.

Provide a Skidmore-Wilhelm calibrator or other acceptable bolt tension measuring device. Use the measuring device to perform the rotational-capacity test and to confirm the following:

- Table 555-4 requirement for the complete fastener assembly;
- Calibration of the wrenches if applicable; and
- Understanding and proper use of the tightening method.

Table 555-4
Minimum Fastener Tension(1)

Nominal Bolt Diameter (Nominal Bolt Diameter and Thread Pitch)	ASTM A325 pounds (kilonewtons)	ASTM A490 pounds (kilonewtons)
½ inch (M12 × 1.75)	12,000 (49)	15,000 (61)
⅝ inch (M16 × 2)	19,000 (91)	24,000 (114)
¾ inch (M20 × 2.5)	28,000 (142)	35,000 (179)
⅞ inch (M22 × 2.5)	39,000 (176)	49,000 (221)
1 inch (M24 × 3)	51,000 (205)	64,000 (257)
1⅛ inch (M27 × 3)	56,000 (267)	80,000 (334)
1¼ inch (M30 × 3.5)	71,000 (326)	102,000 (408)
1⅜ inch (M36 × 4)	85,000 (475)	121,000 (595)

(1) Equal to 70 percent of the specified minimum tensile strength of bolts (as specified for tests of full size ASTM A325 and A490 bolts with UNC threads (metric coarse thread series, ANSI B1.13M) loaded in axial tension) rounded to the nearest 1,000 pounds (1 kilonewton).

For short grip bolts, perform the calibrated wrench verification test using a direct tension indicator with solid plates. Check the direct tension indicator with a longer grip bolt in the tension measuring device before testing short grip bolts. Conform to Subsection 555.16(c)(3) through (6) as applicable for confirming testing frequency, number of tests, and test procedure. Provide documentation of annual testing by an approved testing agency confirming the accuracy of the tension measuring device. Install fasteners with specified washers in properly aligned holes. Tension using methods in Subsection 555.16(c)(3) through (6) to the minimum tension specified in Table 555-4.

When it is impractical to turn the nut, tension the fastener by turning the bolt while preventing the nut from rotating when approved by the CO. Provide adequate capacity and sufficient air to tension each bolt in about 10 seconds if impact wrenches are used.

Do not reuse ASTM A490 fasteners and galvanized ASTM A325 fasteners. If approved, non-galvanized ASTM A325 bolts may be re-used once. Touching up or re-torqueing previously tensioned bolts (which may have been loosened by the tensioning of adjacent bolts) will not be considered reuse provided the tensioning continues from the initial position and does not require greater rotation than that shown in Table 555-5.

Table 555-5[(1)]
Nut Rotation from the Snug-Tight Condition[(2)]

Bolt Length Measured from Underside of Head to End of Bolt	Geometry of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis and Other Face Sloped Not More than 1:20 (Bevel Washer Not Used)	Both Faces Sloped Not More Than 1:20 from Normal to Bolt Axis (Bevel Washers Not Used)
Up to and including 4 diameters	$\frac{1}{3}$ turn	$\frac{1}{2}$ turn	$\frac{2}{3}$ turn
Over 4 diameters, but not exceeding 8 diameters	$\frac{1}{2}$ turn	$\frac{2}{3}$ turn	$\frac{5}{6}$ turn
Over 8 diameters, but not exceeding 12 diameter[(3)]	$\frac{2}{3}$ turn	$\frac{5}{6}$ turn	1 turn

(1) Applicable only to connections where all material within the grip of the bolt is steel.

(2) Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned.

The tolerance is minus 0, plus 30° for bolts installed by one-half turn or less.

The tolerance is minus 0, plus 45° for bolts installed by two-third turn or more.

(3) Determine the required rotation by actual tests in a suitable tension device simulating the actual conditions.

(1) Rotational-capacity tests. Use washers even if not required in the actual installation. Perform job-site rotational-capacity tests for fastener assemblies according to ASTM A325 and the following:

(a) Tighten the fastener to a snug-tight condition according to Subsection 555.16(c)(3). Use the bolt tension measuring device to tighten the fastener two times the required turns shown in Table 555-5 if impact wrenches are used.

(b) Verify the maximum recorded tension is at least 1.15 times the minimum fastener tension shown in Table 555-4. Record the tension and torque.

(c) Verify the measured torque at the maximum recorded tension does not exceed the value obtained by the following equation:

$$Torque_{USC} = 0.25PD \qquad Torque_{Metric} = 0.34PD$$

where:

Torque = Measured torque in foot-pounds (newton-meters)

P = Maximum recorded tension in pounds (newtons)

D = Nominal bolt diameter in feet (meters)

(2) Washers. Conform to ASTM F436. Use a hardened beveled washer where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels.

If necessary, clip washers on one side to within seven-eighths times the bolt diameter measured from the washer center.

Hardened washers are not required for connections using ASTM A325 and ASTM A490 bolts, except under the following conditions:

(a) Use a hardened washer under the turned element when the tensioning is done by the calibrated wrench method.

(b) Use a hardened washer under both the head and the nut when A 490 bolts are installed in material having a specified yield point less than 40 kips per square inch (275 megapascals).

(c) Use a hardened washer conforming to ASTM F436 where ASTM A325 bolts of any diameter or ASTM A490 bolts equal to or less than 1-inch (M24) diameter are installed in oversize or short-slotted holes in an outer ply.

(d) Use $^{5}\!/_{16}$-inch (8-millimeter) minimum thickness hardened washers conforming to ASTM F436 under both the head and the nut instead of standard thickness hardened washers where ASTM A490 bolts larger than 1-inch (M24) diameter are installed in oversize or short slotted holes in an outer ply. Do not use multiple hardened washers with a combined thickness equal to or greater than $^{5}\!/_{16}$ inch (8 millimeters) to satisfy this requirement.

(e) Use a $^{5}\!/_{16}$-inch (8-millimeter) minimum thickness plate washer or continuous bar where ASTM A325 bolts of any diameter or ASTM A490 bolts equal to or less than 1-inch (M24) diameter are installed in a long-slotted hole in an outer ply. Provide a structural grade steel bar or plate washer (that need not be hardened) with standard holes and of sufficient size to cover the slot.

(f) Use a $^{5}\!/_{16}$-inch (8-millimeter) minimum thickness hardened washer conforming to ASTM F436 under both the head and the nut instead of washers or bars of structural grade material where ASTM A490 bolts larger than 1-inch (M24) diameter are installed in long-slotted holes in an outer ply. Do not use multiple hardened washers with a combined thickness equal to or greater than $^{5}\!/_{16}$ inch (8 millimeters) to satisfy this requirement.

Alternate design fasteners that provide a bearing circle on the head or nut of at least the diameter of an ASTM F436 hardened washer may be used without washers.

(3) Turn-of-nut installation method. Install bolts in connection holes and pull the plies to firm contact throughout the connection. Tighten bolts snug-tight beginning with the most rigid part of the connection and proceeding to the free edges. Verify that plies are in firm contact throughout the connection.

Apply the rotation shown in Table 555-5 beginning with bolts in most rigid part of the connection and proceeding to the free edges. Do not allow rotation of the fastener part not turned by the wrench.

Use a bolt tension-measuring device at the start of work to verify that the tension on at least three fastener assemblies for each bolt diameter, length, and grade is at least 5 percent greater than the tension shown in Table 555-4. Periodically test other fastener assemblies when required by the CO.

(4) Calibrated wrench installation method. Install bolts with hardened washers under the turned element and pull the plies to firm contact throughout the connection. Tighten bolts snug-tight beginning with the most rigid part of the connection and proceeding to the free edges.

Set a calibrated wrench to deliver the torque required to produce a bolt tension at least 5 percent greater than the tension shown in Table 555-4. Use the calibrated wrench to tension bolts beginning with the most rigid part of the connection and proceeding to the free edges. Touch up previously tensioned bolts until bolts are tensioned to the prescribed amount.

Use a bolt tension-measuring devise at least once each shift to verify the tension on the fastener assemblies installed. Test at least three fastener assemblies of each bolt diameter, length, and grade installed in that shift. Recalibrate a wrench when the prescribed tension is not achieved or when a significant difference is noted in the surface condition of the bolts, threads, nuts, or washers. When tightening from a snug-tight condition, verify that the wrench adjustment selected by the calibration does not produce a nut or bolt head rotation greater than permitted in Table 555-5. Torque nuts in the tightening direction when measuring the torque using manual torque wrenches.

(5) Direct tension indicator (DTI) installation method. Use DTIs conforming to ASTM F959 and installed according to the manufacturer's recommendations. Position the DTI under the stationary element or place a hardened washer between the DTI and the turned element.

Install bolts with DTIs and required hardened washers and pull the plies to firm contact throughout the connection while holding the stationary element against rotation. Remove and replace all DTIs where the number of spaces in which a 0.005 inches (0.125 millimeters) feeler gage is refused in the DTI exceeds the number listed in the AASHTO, *LRFD Bridge Construction Specifications* table.

For uncoated DTIs used under a stationary or turned element and for coated (galvanized, painted, or epoxy-coated) DTIs used under a stationary element, further tension the bolts until the number of refusals of the 0.005 inches (0.125 millimeters) feeler gage is equal to or greater than the number listed in the AASHTO, *LRFD Bridge Construction Specifications* table. Remove and replace bolts that are tensioned so that no visible gap remains. For coated DTIs used under a turned element, further tension the bolts until all spaces verify that the 0.005 inches (0.125 millimeters) feeler gage shows refusal in all spaces.

Verify the tension in a calibrated bolt-tension measuring device. Use a special flat insert in place of the normal bolt head holding insert. Perform three verification tests for each combination of fastener assembly rotational-capacity lot, DTI lot, and DTI position relative to the turned element (bolt head or nut) to be used on the project. Install the fastener assembly in the tension-measuring device with the DTI located in the same position as in the work. Restrain the element intended to be stationary (bolt or nut) from rotation. Conduct verification tests in two stages according to AASHTO, *LRFD Bridge Construction Specifications* table.

(6) Alternate design bolt installation method. When approved, furnish alternate fasteners that meet the material, manufacturing, and chemical composition requirements of ASTM A325 or ASTM A490 and:

(a) Meet the mechanical property requirements of the same specification in full-size tests, and

(b) Have body diameter and bearing areas under the head and nut; or their equivalent, not less than those provided by a bolt and nut of the same nominal dimension.

Install alternate design bolts in connection holes according to the manufacturer's recommendations and pull the plies to firm contact throughout the connection. Tighten bolts snug-tight without yielding or fracturing the control or indicator element of the fastener.

Further tension fasteners beginning with bolts in most rigid part of the connection and proceeding to the free edges. Proper tensioning of the bolts may require more than a single cycle of systematic partial tensioning. Replace individual fastener assemblies if yielding or fracture occurs before the final tensioning cycle.

Verify the tension according to Subsection 555.16(c)(3), (4), or (5).

(7) Inspection. Inspect the tensioned fasteners in the presence of the CO. Replace or re-tension loose or relaxed fasteners. Cutting with a torch is not permitted for removal of fasteners.

(a) Non-threaded fasteners. Ping each fastener with a hammer to test for soundness.

(b) Threaded fasteners. Use an inspection torque wrench to verify tensioning unless alternate fasteners or DTI devices are used allowing verification by other methods.

Calibrate the inspection torque wrench at least once each inspection day. Individually place three fastener assemblies of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Use a washer under the part turned in tightening each bolt if washers are used on the structure. Use the same material that abuts the part turned in the tension measuring device as used on the structure if washers are not used on the structure. In the calibration device, tighten each bolt to the specified tension. Apply the inspecting wrench to the tightened bolt to determine the torque required to turn the nut or head 5 degrees, approximately 1 inch at a 12-inch (25 millimeters at a 300-millimeter) radius, in the tightening direction. Use the average of the torque required for all three bolts as the job-inspection torque.

Randomly select 10 percent (at least two) of the tensioned bolts on the structure in each connection represented by the test bolts. Apply the job-inspection torque to each selected bolt with the inspecting wrench turned in the tensioning direction. If this torque turns no bolt head or nut, the fastener is properly tensioned. If the torque turns one or more bolt heads or nuts, apply the job-inspection torque to all bolts in the connection. Re-torque and re-inspect fasteners whose head or nut turns.

555.17 Welding. Conform to AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)* for welding, welder qualifications, prequalification of weld details, and inspection of welds. For tubular connections, conform to AWS, *Structural Welding Code – Steel, D1.1 (D1.1M) Section 2, Part D.*

Do not weld or tack brackets, clips, shipping devices, or other non-required material to members unless shown on the drawings.

555.18 Erection. Conform to Section 562 for falsework and forms. Use steel erectors certified under the AISC quality certification program.

(a) Handling and storing material. Place stored material on skids above ground. Keep material clean and properly drained. Place and shore girders and beams upright. Support long members (such as columns and chords) on skids placed close enough together to prevent deflection damage.

(b) Bearings and anchorages. Furnish and install bridge bearings according to Section 564. Verify substructure concrete built under a previous contract was properly constructed before ordering material for the superstructure.

(c) Erection procedures.

(1) Conformance to drawings. Erect according to approved drawings. Submit revised drawings and verification of stresses and geometry for modifications to or deviations from the approved erection procedure for approval.

(2) Erection stresses. Allow for erection stresses locked in the structure as a result of erection methods or equipment that differ from those previously approved. Provide additional material necessary to keep both temporary and final stresses within the allowable limits used in the design.

Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments.

(3) Maintaining alignment and camber. Support structural segments to produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing during erection to provide stability and ensure correct geometry. Provide temporary bracing at any stage of erection.

(d) Field assembly. Clean bearing surfaces and permanent contact surfaces. Assemble material as shown on the drawings and match-marks. Do not hammer, damage, or distort members.

Assemble splices and field connections with at least half the holes filled with fitting-up bolts and cylindrical erection pins before installing and tightening the balance of the high-strength bolts. Use fitting-up bolts that are the same high-strength bolts used in the installation or other bolts of the same nominal diameter. Use cylindrical erection pins with a diameter $^{1}/_{32}$ inch (0.8 millimeter) larger than the bolts. Fill at least a quarter of the holes with fitting-up bolts and at least another quarter with erection pins. Place pins in the corner holes of the splice plates. Fill at least three-fourths of the holes of splices and connections carrying traffic.

Systematically remove fitting-up bolts and cylindrical erection pins and replace them with tightened high-strength bolts. Start from the most rigid part of connection and proceed to the free edges.

Release temporary erection supports at a splice or connection only after bolts are installed and tightened. Show special assembly and support situations on the erection drawings.

(e) Pin connections. Use pilot and driving nuts when driving pins. Drive pins so that the members fully bear on the pins. Screw pin nuts tight and burr the threads at the face of the nut with a pointed tool.

(f) Misfits. Correct minor misfits using small amounts of reaming, cutting, grinding, and chipping. Remove and replace members misfit due to shop fabrication error or deformation during handling or transporting.

555.19 Acceptance. Material (except bearing devices and painting) for steel structures will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of structural steel, steel forgings, and high-strength bolts, nuts, and washers.

Construction of steel structures will be evaluated under Subsections 106.02 and 106.04.

Painting will be evaluated under Section 563.

Bearing devices will be evaluated under Section 564.

Measurement

555.20 Measure the Section 555 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure structural steel computed according to AASHTO, *LRFD Bridge Construction Specifications*. Include metal items incidental to the structure and specified in the contract.

When measurement is by contract quantity, changes in quantities resulting from alternative details proposed by the Contractor and accepted as a part of the drawings are not subject to adjustment according to Subsection 109.05.

Payment

555.21 The accepted quantities will be paid at the contract price per unit of measurement for the Section 555 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 556. — BRIDGE RAILING

Description

556.01 This work consists of furnishing, erecting, removing, and resetting bridge railing.

Bridge railing is designated as concrete, steel, aluminum, or timber according to the predominant material contained in the railing.

Material

556.02 Conform to the following Sections and Subsections:

Aluminum alloy for bridge rail	717.12
Aluminum bolt heads and nuts	717.13
Aluminum welding wire	717.14
Box beam rail	710.06(b)
Painting	563
Reinforcing steel	709.01
Steel structures	555
Structural concrete	552
Timber structures	557

Construction Requirements

556.03 General. Accurately place anchor bolts to provide correct and true alignment of the railing. Set anchor bolts so that they project not more than ⅜ inch (10 millimeters) beyond the nut when tightened. Chamfer or round by grinding or filing sharp exposed metal edges.

Do not erect railing until centering or falsework for the supporting span is removed. Construct bridge railing so that it does not follow unevenness in the curb, sidewalk, or wall that supports the railing. Install railing to present a smooth and uniform appearance in its final position. Set posts vertical.

556.04 Concrete Railing. See Section 552.

556.05 Steel Railing. See Section 555.

556.06 Aluminum Railing. See Section 555, except as amended by the following:

(a) Cutting. Material that is ½ inch (13 millimeters) thick or less may be cut by shearing, sawing, or milling. Saw or mill material that is over ½ inch (13 millimeters) thick. Do not flame cut. Make cut edges true, smooth, and without excessive burrs or ragged breaks. Fillet reentrant cuts by drilling before cutting.

(b) Bending. Material may be heated to a maximum 400 °F (200 °C) for a period not to exceed 30 minutes to facilitate bending.

(c) Rivet and bolt holes. Drill rivet and bolt holes to finished size or subpunch smaller than the nominal diameter of the fastener and ream to size. Subpunch to a diameter that is smaller than that of the finished hole by at least one-quarter the thickness of the piece. Make the finished diameter of holes not more than 7 percent greater than the nominal diameter of the fastener, except:

(1) Fabricate slotted bolt holes as required; and

(2) Fabricate anchor bolt holes up to 25 percent larger, not to exceed ½ inch (13 millimeters) larger than the nominal bolt diameter.

(d) Welding. Weld according to AWS, *Structural Welding Code - Aluminum, D1.2 (D1.2M).*

(e) Contact with other material. Protect aluminum alloys that contact other material as follows:

(1) Aluminum alloys in contact with other metals. Coat the contacting surfaces with dielectric aluminum-impregnated caulking compound or place a synthetic rubber gasket between the surfaces.

(2) Aluminum alloys in contact with stone or concrete.

(a) Where a bond is not required. Coat the contacting surfaces with aluminum-impregnated caulking compound or with heavy bituminous paint pigmented with aluminum powder or paste.

(b) Where a bond is required. Coat the contacting aluminum surface with zinc-chromate paint. Allow paint to dry before installation.

(3) Aluminum alloys in contact with wood. Coat the contacting wood surface with three coats of paint according to Section 563 and coat the contacting aluminum surface with aluminum-impregnated caulking compound.

556.07 Timber Railing. See Section 557.

556.08 Remove and Reset Bridge Railing. Remove and store the existing bridge railings and appurtenances. Replace railings, supports, and hardware damaged during removal, storage, or resetting.

556.09 Painting. When required by the contract, paint according to Section 563.

556.10 Acceptance. Material (except concrete, painting, reinforcing steel, structural steel, and timber) for bridge railings will be evaluated under Section 106.03. Submit a production certification with each shipment of bridge railing.

Concrete will be evaluated under Section 552, except compressive strength will be evaluated under Subsection 106.04.

Construction of bridge railings will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Structural steel will be evaluated under Section 555.

Timber will be evaluated under Section 557.

Painting will be evaluated under Section 563.

Measurement

556.11 Measure the Section 556 pay items listed in the bid schedule according to Subsection 109.02.

Payment

556.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 556 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 557. — TIMBER STRUCTURES

Description

557.01 This work consists of fabricating, treating, erecting, and painting structural timber. This work also includes required lumber and hardware.

Material

557.02 Conform to the following Section and Subsections:

Galvanized coatings (drains)	717.07
Hardware	716.02
Painting	563
Structural carbon steel (drains)	717.01(a)
Structural glued laminated timber	716.04
Treated structural timber and lumber	716.03
Untreated structural timber and lumber	716.01

Construction Requirements

557.03 General. Excavate and backfill according to Section 208.

Use slings or other devices to protect the corners of heavy timbers and banded packages of lighter timber.

Cut and form lumber and timber so joints have even bearing over their entire contact surface. Do not use shims in making joints. Close all joints. Drive nail and spike heads flush with the wood surface.

Use the same end, face, and edge of the timber member for all layout dimensions. Bore holes from mating faces.

557.04 Storing Material. Store material in an area cleared of weeds, rubbish, or other objectionable material. Elevate material at least 8 inches (200 millimeters) above the ground. Provide sufficient support to prevent sagging.

Open-stack untreated material to shed water. Allow for free air circulation by stacking material in layers on stickers that extend across the full width of the stack. Align stickers vertically and space them at regular intervals.

Close-stack treated material to shed water.

Protect material from the elements. Use water-resistant paper or opaque polyethylene film if material is be covered. Do not use impervious membranes (such as polyethylene film) during dry weather. Slit or puncture individual wrappings full length on the lower side to permit water drainage.

Store and protect glued laminated timber according to the AITC 111, *Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage, and Erection.*

557.05 Holes for Drift Pins, Dowels, Bolts, and Lag Screws. Bore holes before preservative treatment.

Bore holes for round drift pins and dowels to a diameter $^{1}/_{16}$ inch (1.6 millimeter) less than the diameter of the pin or dowel. Bore holes for square drift pins and dowels to a diameter equal to the side dimension of the pin or dowel.

Bore holes for galvanized bolts to a diameter $^{1}/_{16}$ inch (1.6 millimeter) larger than the diameter of the bolt.

Bore holes for lag screws according to Subsection 7.3.1. of the AITC, *Timber Construction Manual*.

557.06 Treating Timber. Indicate the preservative used, penetration in inches (millimeters), retention in pounds per cubic foot (kilograms per cubic meter) (assay method).

Cut, frame, and bore timbers before treatment when practical. Do not cut or bore timber below the high-water mark in coastal waters.

Handle treated timber according to the AWPA published Consumer Information Sheet. Do not drip or spill preservative into the aquatic environment or onto the ground. Handle treated timbers to prevent damage to their surfaces. Do not use cant dogs, hooks, or pike poles.

Field treat cuts or abrasions with preservative. Dip, soak, spray, or apply three brush coats of the same preservative according to AWPA M4, *Standard for the Care of Preservative-Treated Wood Products*.

Impregnate holes bored after treatment with the same preservative using tools suitable for proper application. Plug unused holes with the same treated timber.

557.07 Hardware. Galvanize hardware and fasteners including nails, spikes, bolts, washers, and timber connectors. Do not galvanize malleable iron or cast iron hardware.

Use washers under bolt heads and nuts in contact with wood. Use malleable iron washers with a diameter approximately three times the bolt diameter. Use cast iron washers when the timber is in contact with the ground. Use square washers only when specified.

Cut off excess bolt lengths of more than 1 inch (25 millimeters). After final tightening, check or burr bolts with a pointing tool to prevent loosening of the nuts.

557.08 Countersinking. Countersink screws, bolts, and nuts where required. Treat countersunk recesses with an approved preservative before filling, except in railings. Fill the recess with hot pitch or other approved filler after bolts, screws, and nuts are in place.

557.09 Framing. Do not slab or trim treated piles when fitting sway or sash braces. Securely fasten braces to smaller piles using treated blocks to fill the gaps.

557.10 Framing Bents. Firmly and evenly bed mud blocks to solid bearing. Tamp in place.

When concrete is cast, set dowels for anchoring sills and posts to project at least 6 inches (150 millimeters) above the tops of the pedestals. Finish concrete pedestals supporting framed bents so that sills or posts bear evenly on the pedestals.

Make sills bear evenly and true on mud blocks, piles, or pedestals. Bolt sills into place with drift bolts that extend into the mud blocks or piles for at least 6 inches (150 millimeters). Where possible, remove material in contact with sills for circulation of air around the sills.

557.11 Bent Caps. Make timber caps bear evenly and uniformly over the tops of aligned supporting posts or piles. Secure caps with drift bolts extending at least 9 inches (230 millimeters) into the approximate center of each post or pile.

557.12 Bracing. Bolt the ends of bracing through the pile, post, cap, or sill. Brace intermediate intersections with posts or piles with bolts and spikes with wire, or boat spikes as required. Use galvanized spikes in addition to bolts.

Make bracing bear firmly against the pile or cap to which it is bolted. Provide and place shims as necessary to prevent bending of the bracing more than 1 inch (25 millimeters) out of true when bracing bolts are tightened.

Where the space between the bracing and cap or pile is:

(a) Less than 1 inch (25 millimeters), shims are not needed;

(b) 1½±½ inches (38±13 millimeters), place two ogee washers with their narrow faces together or other approved washers on each bolt that passes through the space; or

(c) Over 2 inches (50 millimeters), use wooden shims of the proper thickness.

Fabricate the wooden shims from the same treated wood used in the structure or white oak. Do not use built-up wooden shims. Make wooden shims from a single piece of lumber with the width not less than 4 inches (100 millimeters) and the length not less than the width of the bracing measured along the cap or pile. Do not adze, trim, or cut treated members to avoid the use of shims.

557.13 Stringers. Size stringers at bearings. Position stringers so knots near edges are in the top portion of the stringer.

Outside stringers may have butt joints with ends cut on a taper. Lap interior stringers so both stringer ends have full length bearing on a floor beam or cap. Stagger joints where stringers are two panels in length. Separate lapped ends of untreated stringers by at least ½ inch (13 millimeters) for air circulation. Use drift bolts to securely fasten the lapped ends.

Place cross-bridging at the center of each span. Cut cross-bridging members to provide full bearing on the stinger sides at each end. Securely toenail the cross-bridging with at least two nails in each end. If blocking is used, make it fit snugly and securely.

557.14 Plank Floors. Use plank that is surfaced on four sides (S4S).

Single-ply timber floors consist of a single thickness of planks supported on stringers. Grade plank thickness so no two adjacent planks vary in thickness by more than ⅛ inch (3 millimeters). Lay the planks heart side down with ¼ inch (6 millimeters) space between them for dry, seasoned material and with no joint space for unseasoned material. Spike each plank securely to each stringer.

Two-ply timber floors consist of two layers of flooring supported on stringers. Treat the lower layer according to Subsection 557.06. Lay the top layer either diagonally or parallel to the roadway centerline.

Stagger joints at least 36 inches (900 millimeters). Securely fasten each top layer member to the lower layer. Where the top layer is placed parallel to the centerline of the roadway, use special care to securely fasten the ends of the flooring. Bevel the ends of top layer members at each end of the structure.

557.15 Transversely Nail Laminated Decks. Use 2-inch (50-millimeter) nominal thickness laminations, surface one edge hit or miss ⅛ inch (3 millimeters) scant (S1E-H or M ⅛-inch (3-millimeter) scant), and one side hit or miss ⅛ inch (3 millimeters) scant (S1S-H or M ⅛-inch (3-millimeter) scant).

Place the laminations on edge and at right angles to the centerline of roadway. Attach each piece to the preceding piece using galvanized spikes of sufficient length to pass through two pieces and at least halfway through the third piece. Drive spikes at each end and at approximately 18-inch (450-millimeter) intervals alternately diving near the top and bottom edges.

Where timber stringers are used, use spikes to toenail every other piece to every other stringer. When steel stringers are used, securely attach the pieces using approved galvanized metal clips.

Use pieces of sufficient length to bear on at least four stringers. Do not splice pieces between stringers. Space end joints on a stringer no closer than every third piece. Space end joints in adjoining pieces no closer than every second stringer.

557.16 Glue Laminated Panel Decks. When handling and transporting, avoid bending panels, especially transverse to the laminated pieces. When lifting a panel, support it at a sufficient number of points. Do not drag or skid panels. Protect the panel edges from damage.

When dowels are used between panels, use a template or drilling jig to properly space dowel holes. Drill holes the same diameter as the dowel and ¼ inch (6 millimeters) deeper than one half the dowel length. Slightly taper or round dowel tips and lubricate dowels to facilitate the connection process.

Start the tips of the dowels partially and equally in the holes of the panels to be joined. Draw the panels together, keeping the edges parallel, until the panels abut tightly. Securely fasten each panel to each stringer.

557.17 Wheel Guards and Railings. Surface (S4S) wheel guards, rails, and posts. Place wheel guards in not less than 12-foot (3.7-meter) lengths. Squarely butt-joint rails at posts.

557.18 Trusses. Avoid irregularities in alignment. In horizontal projection, fabricate chords straight and true from end-to-end. In vertical projection, fabricate chords to a smooth, corded curve through panel points conforming to the correct camber. Make bearing surfaces fit accurately. Do not make uneven or rough cuts at the points of bearing.

557.19 Painting. When required by the contract, paint according to Section 563.

557.20 Acceptance. Material for timber structures will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of structural timber and lumber. If treated, indicate the preservative used, penetration inches (millimeters), retention in pounds per cubic foot (kilograms per cubic meter) (assay method), and the "Best Management Practice" used in treating timber members.

Construction of timber structures will be evaluated under Subsections 106.02 and 106.04.

Painting will be evaluated under Section 563.

Measurement

557.21 Measure the Section 557 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring untreated and treated structural timber and lumber by the thousand board feet measure (cubic meters), measure in the structure.

Compute the quantities from nominal dimensions and actual lengths, except for transversely nail laminated decks and glue laminated panel decks. Measure transversely nail laminated decks and glue laminated panel decks in place after dressing.

Measure timber piles under Section 551.

Measure timber bridge rail under Section 556.

Payment

557.22 The accepted quantities will be paid at the contract price per unit of measurement for the Section 557 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 558. — DAMPPROOFING

Description

558.01 This work consists of dampproofing concrete or masonry surfaces.

Material

558.02 Conform to the following Subsections:

Asphalt	702.03(b)
Primer	702.03(a)

Construction Requirements

558.03 Dampproofing. Cure the concrete or masonry surface according to Subsection 552.15, except do not use liquid membrane curing compound. Allow concrete surface to dry at least 10 days after completion of curing.

Apply dampproofing to a dry, clean, reasonably smooth surface that is free of dust and loose material. Apply dampproofing in dry weather when the air and surface temperatures are 45 °F (7 °C) or higher.

Apply primer to the surface and allow it to dry. Apply two coats of asphalt at the rate of approximately 25 pounds per 100 square feet (1.25 kilograms per square meter) of surface per coat. Apply prime coat and asphalt coats uniformly, fully covering the surface, and thoroughly work them into the surface. Make the total of the final two asphalt coats approximately $^{3}\!/_{32}$ inch (2.4 millimeters) thick. Allow asphalt coats to harden before allowing contact with water or backfill material.

558.04 Acceptance. Material for dampproofing will be evaluated under Subsections 106.02 and 106.03.

Applying dampproofing will be evaluated under Subsections 106.02 and 106.04.

Measurement

558.05 Measure the Section 558 pay items listed in the bid schedule according to Subsection 109.02.

Payment

558.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 558 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 559. — WATERPROOFING

Description

559.01 This work consists of waterproofing concrete surfaces. Waterproofing consists of in-place membrane or preformed membrane systems.

Material

559.02 Conform to the following Subsections:

Asphalt	702.03(b)
Asphalt roll roofing	702.03(e)
Mastic	702.03(d)
Primer	702.03(a)
Sealants, fillers, and seals	712.01
Waterproofing fabric	702.03(c)

Construction Requirements

559.03 General. Store waterproof fabric in a dry and protected place. Do not store rolls standing on end.

Ensure the concrete surface is free of projections or depressions that might cause puncture of the membrane. Clean the concrete surface of dust and loose material. Do not place membranes on wet concrete. Do not place membrane on new concrete until at least 10 days after completion of the concrete curing process as defined in Subsection 552.15. Apply waterproofing in dry weather when the temperature is above 35 °F (2 °C) and rising.

Apply primer and membrane beginning at the lowest point of the work.

559.04 In-place Membrane System. Stir asphalt frequently as it is heated to a temperature between 300 and 350 °F (150 and 175 °C).

Apply hot asphalt at a rate not less than 12 gallons per 100 square feet (5 liters per square meter) on finished horizontal surface and not less than 15 gallons per 100 square feet (6 liters per square meter) on vertical surface.

Ensure placed fabric is mopped by end of shift.

Prevent water from getting between the waterproofing and the waterproofed surface at the edges and at openings in the membrane for drains and pipes.

Provide flashing at curbs and against girders, spandrel walls, and other area with separate sheets that lap the main membrane at least 12 inches (300 millimeters). Seal flashing with either a metal counter-flashing or by embedding the upper edges of the flashing in a groove joint filler.

Provide horizontal and vertical expansion joints with sheet copper or lead in a "*U*" or "*V*" form. Fill the joint with hot joint filler after the membrane has been placed. Carry the membrane continuously across expansion joints. For joints that are essentially open joints, but are not designed to provide for expansion, pack the joint with oakum and fill with hot-poured joint filler before placing the membrane.

At the ends of a structure, carry the membrane down the fill face of the abutment and provide for movement.

Install material as follows:

(a) Apply a coat of primer and allow to dry;

(b) Mop a coat of hot asphalt slightly wider than half the width of waterproof fabric and cover the entire area of concrete;

(c) Immediately roll a starter strip of half-width waterproof fabric into the asphalt. Press the waterproof fabric into place to rid it of air bubbles and to conform it closely to the surface;

(d) Mop hot asphalt over the top of the starter strip to completely conceal the weave and an adjoining section of concrete surface slightly wider than half the fabric width;

(e) Immediately roll a full-width strip of fabric into the fresh asphalt, pressing it into place as before;

(f) Mop this second strip and an adjoining section of concrete surface slightly wider than half the fabric width;

(g) Place a third strip of fabric to lap the first strip by not less than 4 inches (100 millimeters). Continue this process of lapping each strip of fabric at least 4 inches (100 millimeters) over the strip placed before the last strip until the entire surface is covered with 2 layers of fabric. Lap the ends at least 12 inches (300 millimeters). Do not allow the fabric to touch an un-mopped surface; and

(h) Mop the entire surface with hot asphalt after all waterproof fabric has been placed.

Ensure laps are sealed.

Repair or replace waterproofing that leaks. Use patches extending at least 12 inches (300 millimeters) beyond the outermost damaged portion, and extend the second ply at least 3 inches (75 millimeters) beyond the first.

Apply protective covering according to Subsection 559.06.

559.05 Preformed Membrane System. Preformed membrane systems consist of a primer applied to the prepared surface and a single layer of adhering preformed membrane sheet.

(a) Prime application. Install oil-resistant, adhesive-backed construction paper to mask expansion dams or headers.

Thoroughly mix and apply primer by spray or squeegee to the entire area to be sealed. Apply the neoprene-based primer in one coat at a rate of approximately 300 square feet per gallon (7 square meters per liter). Apply resin or solvent-based primer in one coat at a rate of approximately 120 square feet per gallon (3 square meters per liter). Continuously agitate the primer during application.

(b) Membrane installation. Place the membrane continuously over masked areas. Place the membrane on neoprene-based primers within 36 hours, resin-based primers within 8 hours, and solvent-based primers within 24 hours of placing the primer. If this time is exceeded, re-apply the primer.

Place the membrane by hand or by mechanical methods. Lap membrane sheets in the direction of water flow.

(1) Bridge decks.

(a) Install a 12-inch (300-millimeter) minimum width strip along the juncture of deck and base of barrier railing or curb face at the low side of the deck with the sheet extending up the face 3 inches (75 millimeters);

(b) Starting at the gutter line, lay sheets longitudinally and side lapped with adjacent sheets by not less than 2½ inches (60 millimeters) and end lapped by not less than 6 inches (150 millimeters);

(c) Place a 12-inch (300-millimeter) minimum width strip at the juncture of deck and base of curb or railing at the high side of the deck extending up the face 3 inches (75 millimeters).

(d) At open joints, at deck bleeder pipes, and at other locations as needed, cut the membrane sheet and turn into the joint or bleeder as the sheet is being laid; and

(e) For rubberized asphalt sheets and modified bitumen sheets, apply mastic as a bead along the exposed edge of the membrane sheet that extends up the barrier railing or curb face and that ends in the high-side gutter.

(2) Surfaces other than bridge decks. Conform to Subsection 559.05(b)(1) and the following:

(a) Place membrane vertically with each successive sheet lapped to the preceding by at least 3 inches (75 millimeters);

(b) Lap horizontal splices by at least 6 inches (150 millimeters);

(c) Place a troweled bead of manufacturer’s recommended mastic or sealing tape along exposed edges of the installed membrane;

(d) Flash projecting pipe, conduits, sleeves, or other facilities passing through the preformed membrane waterproofing; and

(e) Use prefabricated or field-fabricated boots, fitted coverings, or other devices as necessary to provide watertight construction.

Roll the surface with hand rollers or other apparatus as necessary to develop a firm and uniform bond with the primer and minimizes wrinkles and air bubbles.

Patch tears, cuts, or narrow overlaps using a satisfactory adhesive and by placing sections of membrane sheet over the defective area such that the patch extends at least 6 inches (150 millimeters) beyond the defect. On modified bitumen sheets with a permanent polyester film, use a propane torch to melt the polyester film on the section to be patched, then place the patch over the heated surface. Press or roll patches firmly onto the surface.

Apply a protective coving.

559.06 Protective Coving. Apply a protective covering immediately after waterproofing to prevent damage to the membrane from sunlight, weather, traffic, or construction operations.

For waterproofed surfaces against which backfill will be placed, cover the membrane with ⅛ inch (3 millimeters) thick hardboard or other approved material.

559.07 Alternate Membrane Systems. Submit for approval waterproofing membrane systems from the state department of transportation's Qualified Products List (QPL) that complies with the maximum profile grade and superelevations shown in the plans.

Construct alternate membrane systems according to the manufacturer's recommendations and as approved by the CO.

559.08 Overlay Placement. Limit traffic on the membrane to necessary construction equipment and emergency vehicles. For roadway surfaces of bridge decks, place a protective layer of asphalt concrete pavement as specified.

Place the overlay continuously over masked areas and subsequently cut at or near the expansion joint after the overlay is in place. Place a hot asphalt concrete overlay within 48 hours after placing the membrane.

Do not windrow asphalt concrete on the membrane ahead of the paving machine. Do not use an asphalt concrete pickup machine. Do not turn equipment on the membrane to avoid membrane movement and damage. Avoid abrupt starts and stops.

Sweep the membrane surface before placing the overlay. Repair damaged areas on the membrane before commencing overlay placement. Apply a light tack coat according to Section 412 before placing the overlay.

Limit the lay-down temperature of the mix to a maximum of 300 ºF (150 ºC).

559.09 Acceptance. Material for waterproofing will be evaluated under Subsections 106.02 and 106.03.

Applying of waterproofing will be evaluated under Subsections 106.02 and 106.04.

Measurement

559.10 Measure the Section 559 pay items listed in the bid schedule according to Subsection 109.02.

Payment

559.11 The accepted quantities will be paid at the contract price per unit of measurement, for the Section 559 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 560. — REMOVAL OF CONCRETE BY HYDRODEMOLITION

Description

560.01 This work consists of removing concrete with high pressure water jets.

Material

560.02 Conform to the following Subsection:

Water	725.01(c)

Construction Requirements

560.03 Submittal. Submit the following for approval by the CO:

(a) Sequence and schedule of work;

(b) Concrete removal procedures; and

(c) List of equipment to be used.

560.04 General. Furnish water required to operate the hydrodemolition equipment.

Protect adjacent property from dislodged concrete during operations. Construct debris shields to prevent debris and wastewater from entering waterways, travel lanes open to public traffic, or areas designated not to be disturbed.

Use filtering methods to ensure wastewater is free of concrete particles and sediment.

Dispose of wastewater and debris off the project according to Subsection 203.05.

560.05 Equipment.

(a) Hydrodemolition system. Furnish a self-propelled and completely programmable hydrodemolition system designed for concrete removal as specified.

Calibrate equipment to specific project parameters before beginning hydrodemolition production work. If hydrodemolition equipment cannot be calibrated to the satisfaction of the CO, remove equipment and provide another hydrodemolition system. Adjust equipment at the beginning of each day on an area of representative concrete designated by the CO before commencing operations. Verify settings will remove concrete as specified. Adjust settings as necessary to achieve the desired removal of concrete. Recalibrate during the work if parameters change (such as degree of concrete deterioration or the concrete strength changes).

Record the following settings and notify the CO:

(1) Water pressure gauge;

(2) Water usage in gallons (liters) per minute;

(3) Machine staging control (step) – feet (meters) per minute forward travel;

(4) Nozzle size;

(5) Nozzle speed (revolutions per minute);

(6) Transverse nozzle travel speed. Only applicable if hydrodemolition nozzle is not fixed and moves transversely on a track between stops before staging to the next step. Report transverse nozzle travel speed in feet (meters) per second; and

(7) Effective pass width of hydrodemolition unit. Effective pass width is defined as the width of hydrodemolition that has uniform pressure, water, and dwell time per machine staging control (step). Report effective width in feet (meters).

(b) Vacuum System. Furnish a vacuum system equipped with:

(1) Fugitive dust control devices capable of removing wet debris and water in the same pass; and

(2) A pressurized washing system capable of cleaning the concrete surface during the vacuum operation to dislodge debris and slurry.

560.06 Concrete Removal. Remove concrete as follows:

(a) Shallow concrete removal for deck scarification. If a hydrodemolition machine is used for concrete scarification in preparation for a deck overlay, clean the deck by an approved method of water blasting with 7000 pounds per square inch (335 kilopascals) minimum pressure until sound concrete is exposed. Scarify to the depth shown in the plans. If no depth is shown, remove at least ¼ inch (6 millimeters) of material.

(b) Concrete cover removal. For planned removal of concrete or removal of unsound or deteriorated concrete, remove concrete to the depth shown in the plans or down to sound concrete. Provide at least 1 inch (25 millimeters) below the bottom of the exposed reinforcing steel. When removing unsound concrete be careful to remove only to the depth that sound concrete is encountered provided it meets the at least 1 inch (25 millimeters) below the bottom of the reinforcing steel. Do not damage remaining sound concrete or reinforcing steel. When the bond between existing concrete and reinforcing steel is destroyed, remove the concrete adjacent to the reinforcing steel to a depth that permits new concrete to bond to the reinforcing steel.

Remove loose and unsound concrete resulting from the hydrodemolition operations below the minimum depth.

Verify concrete removal as necessary or at least every 30 feet (9 meters) along the cutting path.

In areas inaccessible to the hydrodemolition equipment, use approved hand-held water blasting equipment or power-driven hand tools (such as jack hammers, mechanical chipping tools, or chipping hammers). Do use jack hammers heavier than nominal 30 pound (14 kilogram) class and chipping hammers heavier than 15 pound (7 kilogram) class. Operate mechanically driven tools at a maximum angle of 45 degrees from the concrete surface.

If necessary, use hand tools (such as hammers and chisels) to remove the final particles of concrete to achieve the required depth. Leave a rough surface after the concrete is removed.

Immediately remove residue, water, dust, and concrete to prevent rebonding to the surface or reinforcing steel.

560.07 Reinforcing Steel. Do not cut or damage reinforcing steel designated to remain. Use methods acceptable to the CO to repair or replace reinforcing steel damaged by operations.

Inspect the reinforcement with the CO after the concrete has been removed. Replace reinforcing steel by tying new reinforcing steel to the existing reinforcing steel when more than 10 percent of its section is lost. If the deteriorated portion of the reinforcing steel is closer to the edge of the patch than the overlap distance designated in the plans, extend the limits of the patch to provide the required overlap distance with acceptable reinforcing steel. Provide a minimum 2-inch (50-millimeter) clearance between the ends of new reinforcing steel and the existing slab face. Match the number, type, and spacing of the new reinforcement steel to the existing reinforcing steel.

560.08 Surface Preparation. Before placing new concrete, clean the concrete surface and exposed reinforcing steel of rust, loose and rebounded material, and other contaminants that may inhibit bonding with new concrete. If compressed air is used, provide a filter in the air line to ensure that the air delivered is oil-free. Protect the steel and surface from contamination until the new concrete is placed.

560.09 Acceptance. Removal of concrete by hydrodemolition will be evaluated under Subsection 106.02 and 106.04.

Measurement

560.10 Measure the Section 560 pay items listed in the bid schedule according to Subsection 109.02.

Payment

560.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 560 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 561. — STRUCTURAL CONCRETE INJECTION AND CRACK REPAIR

Description

561.01 This work consists of repairing cracks in concrete structures by injecting epoxy into the cracks.

Material

561.02 Conform to the following Subsection:

Epoxy resin adhesives	725.18
Polymer concrete and mortar	725.14

Construction Requirements

561.03 Crack Preparation. Notify the CO at least 14 days before beginning work. The CO will identify work areas and mark the cracks to be repaired.

Submit the following for approval 14 days before beginning work:

(a) Personnel qualifications;

(b) The manufacturer’s recommended material; and

(c) Describe the material to be used including the properties of each material and the specifications to which the material comply.

An injection procedure for performing the work.

Remove dirt, laitance, and other debris from the exterior and interior of the crack. Apply a temporary surface seal material to the face of the crack. Use a surface seal material with sufficient strength and adhesion to confine the injected epoxy resin adhesive until cured.

Provide openings (entry ports) in the surface seal along the crack. Make the distance between entry ports at least the thickness of the concrete member being repaired.

561.04 Injection Procedure. Maintain the epoxy resin adhesive component mix ratio within 5 percent by volume as prescribed by the manufacturer. Do not use solvents to thin the epoxy.

Use positive inline displacement type equipment to meter, mix, and inject the epoxy at pressures not to exceed 200 pounds per square inch (1380 kilopascals). Begin injecting epoxy at the lowest entry port. Continue the injection at the first port until epoxy flows from the next highest port. Plug the first port and inject epoxy into the second port until epoxy flows from the next highest port. Continue this sequence until the entire crack is filled.

Perform the following tests for each injection unit at the beginning and at the end of each day the unit is used.

(a) Ratio check test. Disconnect the mixing head of the injection equipment. Pump the two adhesive components through a ratio check device having two independent valved nozzles capable of controlling the flow rate and back pressure by opening or closing the valves. Use a pressure gauge capable of sensing back pressure behind each valve. Adjust the discharge pressure to 200 pounds per square inch (1380 kilopascals) for both epoxy components. Simultaneously discharge both epoxy components into separate calibrated containers. Compare the discharged quantities to determine the mix ratio.

After the test is completed at 200 pounds per square inch (1380 kilopascals) discharge pressure, repeat the procedures for 0 pounds per square inch (0 kilopascals) discharge pressure.

(b) Pressure check test. Disconnect the mixing head of the injection equipment. Attach the two adhesive component delivery lines to a pressure check device having two independent valved nozzles capable of controlling the flow rate and pressure by opening or closing the valves. Use a pressure gauge capable of sensing the pressure build-up behind each valve. Close the valves on the pressure-check device and operate the equipment until the gauge pressure on each line reads 200 pounds per square inch (1380 kilopascals). Stop the pumps and check that the gauge pressure does not drop below 190 pounds per square inch (1310 kilopascals) within 3 minutes.

(c) Records. Maintain and make available complete and accurate records of the ratio and pressure check tests. Additional ratio and pressure check tests may be required.

561.05 Coring. Take one 2-inch (50-millimenter) diameter test core according to AASHTO T 24 for every 50 feet (15 meters) of repaired crack at designated locations. The crack repair is acceptable when the epoxy bonding has penetrated at least 90 percent of the crack volume within the core sample.

When a test core is unacceptable, redo that 50-foot (15-meter) crack segment or the segment that the core represents and resample. Repeat this procedure until acceptable crack repair is achieved.

561.06 Finishing. Remove the surface seal and fill sample core holes with polymer concrete and mortar. Finish the face of the crack, the entry ports, and the core holes flush with the adjacent surface and finish the surface to match the adjacent concrete.

561.07 Traffic Control. Provide traffic control beginning with the application of epoxy paste surface seal. Continue providing traffic control for 6 hours after completion of the crack injection work or until the injected epoxy resin adhesive has reached a compressive strength of at least 1,450 pounds per square inch (10 megapascals), whichever is less.

Provide traffic control to slow traffic to a maximum speed of 15 miles (25 kilometers) per hour.

For bridge deck repairs, stage traffic so that the edge of the nearest travel lane is no closer than the center of the adjacent girder, unless specified in the contract.

561.08 Acceptance. See Table 561-1 for sampling, testing, and acceptance requirements.

Material for structural concrete injection and crack repair will be evaluated under Subsections 106.02 and 106.03.

Structural concrete injection and crack repair work will be evaluated under Subsections 106.02 and 106.04.

Measurement

561.09 Measure the Section 561 pay items listed in the bid schedule according to Subsection 109.02.

Payment

561.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 561 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 561-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Daily Start-up & Shutdown Testing									
Epoxy resin adhesive	Process control (153.03)	Ratio check (Mix)	−	Subsection 561.04(a)	Daily before starting work and after ending work	Injection unit	No	Subsection 561.04(c)	
		Pressure check	−	Subsection 561.04(b)	"	"	"	"	
Production									
Epoxy resin adhesive	Measured and tested for conformance (106.04)	Penetration of material into crack	−	Subsection 561.05	1 core for every 50 feet (15 meters) of repaired crack length	In-place after epoxy resin injection completed	No	Upon completion of test	

Section 562. — TEMPORARY WORKS

Description

562.01 This work consists of the design, construction, inspection, maintenance and removal of temporary works for the construction and repair of permanent structures. This work also includes temporary facilities used in construction that do not become part of the permanent structure.

Material

562.02 Select material consistent with the safety and quality required by the design assumptions.

Furnish factory fabricated components of vertical shoring towers according to FHWA-RD-93-033, *Certification Program for Bridge Temporary Works*.

Design Requirements

562.03 Design. Design temporary works that will support loads imposed and provide the necessary rigidity to produce the lines and grades shown in the plans for the final structure. Design temporary works according to the AASHTO, *Load and Resistance Factor Design (LRFD) Bridge Design Specifications* or AASHTO, *Guide Design Specifications for Bridge Temporary Works*. Ensure the design load on manufactured devices is within the load rating recommended by the manufacturer.

Design falsework and forms that support deck slabs and overhangs on girder bridges to ensure no differential settlement between the girders and the deck forms during placement of deck concrete.

Limit the calculated deflections of falsework and formwork members for cast-in-place concrete structures as follows:

(a) Falsework member vertical deflection: $\frac{1}{360}$ of the span under the dead load of the concrete only, regardless of the fact that deflection may be compensated for by camber strips;

(b) Formwork (other than sheathing): $\frac{1}{360}$ of the span under the dead load of the concrete only or the lateral pressure of fluid concrete only; and

(c) Formwork (sheathing): ⅛ inch (3 millimeters) or $\frac{1}{270}$ of the center-to-center distance between studs, joists, form stiffeners, form fasteners, or wales.

Design falsework and forms for concrete supported on steel structures to ensure loads are applied to girder webs within 6 inches (150 millimeters) of a flange or stiffener. Distribute the loads in a manner that does not produce local distortion of the web. Brace or tie exterior girders, upon which overhanging bridge deck falsework brackets are hung, to the adjacent interior girders as necessary to prevent rotation of exterior girders or overstressing the exterior girder web.

Submit foundation design calculations and other relevant foundation design data for approval.

Do not use deck overhang form brackets that require holes to be cast or drilled into the bridge girders.

Do not apply loads to existing, new, or partially completed structures in excess of the load carrying capacity of any part of the structure as determined according to AASHTO, *LRFD Bridge Design Specifications*.

Do not use permanent or stay-in-place deck forms unless specified.

562.04 Drawings. Submit drawings according to Subsection 104.03. Furnish design calculations and supporting data in sufficient detail to permit a structural and safety review of the proposed design. Show information to allow the design of components to be checked independently. Provide catalog or equivalent data indicating a manufactured device's recommended safe load capacity.

Indicate the proposed sequence, rate of placement, direction of placement, and location of construction joints when concrete placement is involved. Show anticipated total settlements and deflections of the falsework and forms. Include falsework footing settlements, joint take-up, and deflection of beams or girders.

Submit the erection procedure and temporary support system for steel girder erection. Include calculations in sufficient detail to substantiate that the girder geometry is correct. Provide supporting calculations showing the falsework design accommodates the erection procedure without over stressing the structural steel and produces the required final structural geometry, intended continuity, and structural action.

Construction Requirements

562.05 Foundations. Determine the allowable bearing capacity of the foundation material on which the supports for temporary works will rest. Perform load tests to verify proposed bearing capacity values that are in doubt, marginal or in other high risk situations.

Specified foundation support values for the permanent structure may be used in the design of falsework foundations provided foundations are at the same elevation and on the same soil as those of the permanent structure. If temporary works are to be supported on temporary fill, construct the fill according to Section 204 and verify the bearing capacity of the placed material.

Do not locate the edge of footings closer than 12 inches (300 millimeters) from the intersection of the bench and the top of the slope. Do not locate the edge of the footings closer than 48 inches (1200 millimeters) or the depth of excavation, whichever is greater from the edge of excavation, unless shoring adequately supports the footing excavation.

Provide adequate site drainage and erosion control protection to ensure the integrity of the foundation material for the temporary works supports.

If piles are used, capacities may be estimated and later confirmed during construction using standard procedures based on the driving characteristics of the pile. Use the dynamic formula according to Section 551 to determine ultimate pile capacity in the absence of more sophisticated methods of determining pile capacity. The Contractor may use load tests to confirm the estimated capacities. Perform load tests to verify proposed bearing capacity values that are in doubt, marginal, or in other high risk situations.

562.06 Construction. Construct temporary works according to the approved drawings and the AASHTO, *Construction Handbook for Bridge Temporary Works*. Use material and workmanship consistent with that assumed in the design of the temporary works.

Do not weld or use driven devices to fasten temporary works to portions of the permanent structure unless shown on the approved drawings.

Furnish and place form panels for exposed surfaces in uniform widths of not less than 36 inches (900 millimeters) and in uniform lengths of not less than 6 feet (1.8 meters), except where the width of the member formed is less than 36 inches (900 millimeters). Arrange panels in symmetrical patterns conforming to the general lines of the structure. Place panels for vertical surfaces with the long dimension horizontal and with horizontal joints level and continuous. Place panels with the long dimension parallel to the footing for walls with sloping footings and that do not abut other walls. Align form panels on each side of the panel joint by supports or fasteners common to both panels.

Devices may be cast into the concrete for later use in supporting forms or for lifting precast members. Do not use driven devices for fastening forms or form supports to concrete. Use form ties consisting of form bolts, clamps, or other devices necessary to prevent spreading of the forms during concrete placement. Do not use form ties consisting of twisted wire loops.

Make the angle points for chords in wall stems fall at vertical rustication joints when architectural treatment is required. Form exposed curved surfaces to follow the shape of the curve, except on retaining walls that follow a horizontal curve. The wall stems may be a series of short chords if all of the following apply:

(a) Chords within the panel are the same length;

(b) Chords do not vary from a true curve by more than ½ inch (13 millimeters) at any point; and

(c) All panel points are on the true curve.

Provide tell-tales with surveyed measurements, or other acceptable means, for accurate measurement of falsework settlement. Do not use the ground surface near falsework supports as a reference elevation. Record settlement to the nearest ⅛ inch (3 millimeters) during concrete placement.

Discontinue concrete placement and take corrective action if settlement or deflections occur that deviate more than ⅜ inch (10 millimeters) from those shown on the falsework drawings. If satisfactory corrective action is not taken before initial set, remove unacceptable concrete.

562.07 Maintenance and Inspection. Inspect and maintain temporary works in an acceptable condition. Clearly mark the capacity on each manufactured component according to FHWA-RD-93-033.

Perform an in-depth inspection of the temporary works in the presence of the CO not more than 24 hours before beginning each concrete placement, or before allowing people to enter a cofferdam or excavation support structure. Perform inspections and provide certifications according to FHWA-RD-93-033. Submit written results of the inspections before:

(a) Placing concrete;

(b) Allowing people to enter a cofferdam or excavation support structure; or

(c) Loading temporary works.

Inspect other temporary works at least once a month to ensure they are functioning properly. Use a professional engineer to inspect cofferdams, shoring, support of excavation structures, and support systems for load tests before loading.

Include a certification that the system meets the requirements.

562.08 Removal. Remove temporary works, except as follows:

(a) Portions of driven falsework piles that are more than 12 inches (300 millimeters) below subgrade within roadbeds, 24 inches (600 millimeters) below the original ground or finished grade outside of roadbeds, or 24 inches (600 millimeters) below the established limits of a navigation channel;

(b) Footing forms where their removal would damage the structural integrity of the cofferdams or other work; and

(c) Forms from enclosed cells where access is not provided.

Remove temporary works as to permit the structure to uniformly and gradually take the stresses due to its own dead-load.

Remove temporary works upon completion of the work unless permitted to remain. Do not disturb or damage the finished work. Remove debris and restore the area to its original or planned condition. The removed temporary works remain the property of the Contractor.

After the concrete has been in place for 24 hours, removal of railing and barrier forms and forms that do not support the dead load of concrete members is permitted. Do not remove forms until the concrete has reached at least 500 pounds per square inch (3.5 megapascals) strength and in a manner that produces no damage to the surface. Cure concrete according to Subsection 552.15 when forms are removed less than 7 days after concrete placement.

Do not remove forms supporting the dead load of concrete members until the concrete has reached 90 percent of the design compressive strength and has been in place for at least 7 days.

Do not remove falsework supporting any span of a simple span bridge until the concrete, excluding concrete above the bridge deck, has reached 90 percent of the design compressive strength and has been in-place at least 10 days.

Do not remove falsework supporting any span of a continuous or rigid frame bridge until the concrete in that span and in the adjacent portions of each adjoining span for a length equal to at least one-half the length of the span where the falsework is to be released meets the requirements for simple span bridges.

Do not release falsework for post-tensioned portions of structures until the prestressing steel has been tensioned.

Remove falsework for arch bridges uniformly and gradually. Begin at the crown and work toward the springing points. Remove falsework for adjacent arch spans simultaneously.

Install a reshoring system if falsework supporting the sides of girder stems with slopes steeper than 1V:1H are removed before placing deck slab concrete. Design the reshoring system with lateral supports, which resist rotational forces acting on the stem, including those caused by the placement of deck slab concrete. Install the lateral supports immediately after each form panel is removed and before release of supports for the adjacent form panel.

562.09 Acceptance. Temporary works will be evaluated under Subsections 106.02, 106.03, and 106.04.

Measurement and Payment

562.10 Do not measure temporary works for payment. See Subsection 109.05.

Section 563. — PAINTING

Description

563.01 This work consists of removing and applying paint.

Material

563.02 Conform to the following Section and Subsection:

Paint	719
Water	725.01(a)

Construction Requirements

563.03 Qualifications. Provide the following:

(a) Painting contractors certified according to SSPC QP1, *Certification (Field Application to Complex Industrial and Marine Structures)*, SSPC QP2, *Certification Program (Field Removal of Hazardous Coatings)*, or SSPC QP3, *Certification Program (Shop Painting Certification Program)* as appropriate for the work.

When painting more than 1,500 square feet (140 square meters) of steel surface, demonstrate qualifications by obtaining SSPC QP 1 certification for field painting or either SSPC QP 3 certification or the AISC Sophisticated Paint Endorsement (SPE) for shop painting. Maintain the qualification throughout the work. Notify the CO if the qualification expires or is revoked.

(b) Competent personnel according to SSPC QP 2 with the following:

(1) SSPC Competent Person Certificate;

(2) Certificate of completion of 29 CFR 1926.62, Lead in Construction training;

(3) Minimum of 2 years' industrial field painting experience; and

(4) Minimum of 90 days of field supervisory or management experience in paint removal projects.

563.04 Submittals. Submit a written plan for approval at least 14 days before beginning work that details the measures to be used for protecting the environment, public, adjacent property, and workers. Include the following:

(a) Manufacturer's MSDS and product data sheets for cleaning and painting products.

(b) A detailed containment plan for removed material, cleaning products and paint.

Design and construct safe containment structures that will support the loads imposed. Do not apply loads to the existing structure in excess of the load carrying capacity of any part of the structure. Include details of attachment. Make connections that do not require welding or drilling holes in the existing structure. Make connections with clamps or other approved devices. Submit working drawings and construction details according to Subsection 104.03.

(c) A detailed disposal plan for removed material, used cleaning products, and paint debris.

(d) Specific safety measures to protect workers from site hazards including falls, fumes, fires, or explosions.

(e) If paint being removed is a hazardous material, include specific safety measures to comply with 29 CFR 1926.62, 40 CFR 50.6, 40 CFR 50.12, and 40 CFR Parts 260-268. Document compliance upon request.

(f) Emergency spill procedures.

(g) Certifications and experience according to Subsection 563.03.

563.05 Protection of Public, Property, and Workers. Comply with SSPC-PA, *Guide 10 – Guide to Safety and Health Requirements for Industrial Painting Projects* and OSHA requirements.

If a hazardous material containing lead or chromium is removed, comply with the following:

(a) SSPC *Guide 6 – Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations*;

(b) SSPC *Guide 7 – Guide to the Disposal of Lead-Contaminated Surface Preparation Debris*;

(c) 29 CFR 1926.62 – *Lead* (OSHA Safety and Health Regulations for Construction);

(d) 40 CFR 50.6 – *EPA National Primary and Secondary Ambient Air Quality Standards for PM_{10} (EPA)*;

(e) 40 CFR 50.12 – *EPA National Primary and Secondary Ambient Air Quality Standards for Lead*; and

(f) 42 U.S.C. §6901 – *Resource Conservation and Recovery Act (RCRA)*.

Collect and dispose of material including waste water that is used in preparing, cleaning, or painting according to Subsection 107.01.

563.06 Protection of the Work. Use tarps, screens, paper, cloth, or other suitable means to protect adjacent surfaces that are not to be painted. Prevent contamination of freshly painted surfaces by dust, oil, grease, or other harmful or deleterious material.

563.07 General. Perform work according to the accepted plan in Subsection 563.04. Stop work and take corrective action if the measures fail to perform as intended.

(a) Surface preparation. Notify the CO at least 7 days before beginning operations. Perform the following:

(1) Remove dirt, dust, and other contaminants from the surface using methods recommended by the paint manufacture; and

(2) Clean the surface to the specified cleanliness level.

(b) Paint. Conform to the following:

(1) Handling and storing material. Use safe handling practices conforming to the manufacturer's MSDS and product data sheets. Store paint in original unopened containers with labels intact and in weather-tight spaces where temperature is maintained between 40 and 100 °F (4 and 38 °C). Do not open paint containers until required for application that day. Do not use paint from a punctured container or from a container with its lid seal broken. Do not use paint with an expired shelf life.

Mix paint according to the manufacturer's recommendations. Mix paint with mechanical mixers for sufficient time to thoroughly blend the pigment and solvent together. Continue the mixing during application. Do not thin paint that is formulated ready for application. Strain paint after mixing, except where application equipment is provided with strainers. Use strainers of a size to remove only skins and undesirable matter, but not to remove the pigment. Where a skin has formed in the container, cut the skin loose from the sides of the container and remove and discard it. If the volume of the skin is visually estimated to be more than 2 percent of the remaining paint, discard the paint.

(2) Surface preparation and weather limitations. Thoroughly dry the surface to be painted. If no information is provided, apply paint when:

(a) The surface temperature is between 50 and 100 ºF (10 and 40 ºC);

(b) The surface temperature is 5 ºF (3 ºC) or more above the dew point according to ASTM D4230; and

(c) The humidity is 85 percent or less, unless specified otherwise on the manufacturer's product data sheets.

Provide a controlled environment to meet requirements when necessary.

(3) Application. Apply paint according to the manufacturer's recommendations. Apply paint by brush, spray, roller, or combination of methods permitted by the manufacturer's product data sheet.

(a) Brushes. Use brushes with sufficient bristle body and length to spread the paint in a uniform film. Use round, oval shaped brushes, or flat brushes no wider than 4½ inches (120 millimeters). Evenly spread and thoroughly brush out the paint as it is applied.

(b) Sprayers. Use airless or conventional spray equipment with suitable traps, filters, or separators to exclude oil and water from the compressed air. Use compressed air that does not show black or wet spots when tested according to ASTM D4285. Use the spray gun tip sizes and pressures recommended by the manufacturer.

(c) Rollers. Select rollers and covers suitable for the surface and paint to be applied. Use rollers only on flat, even surfaces. Do not use rollers that leave a stippled texture in the paint film.

Use sheepskin daubers, bottle brushes, or other acceptable methods to paint surfaces that are inaccessible for painting by regular means.

Paint in a neat and workmanlike manner that does not produce excessive paint build-up, runs, sags, skips, holidays, or thin areas in the paint film. Correct thin areas, skips, holidays, and other deficiencies before the next application of paint.

Tint succeeding applications of paint to contrast with the paint being covered. Obtain color approval for the finish coat before application.

Paint surfaces that will be inaccessible after erection with the full number of undercoats required before erection. After erection, thoroughly clean areas where the undercoating is damaged or deteriorated, and spot coat these with the specified undercoats to the required thickness before applying the final coat.

Measure the wet film thickness during application and adjust the application rate to obtain the required dry film thickness.

(4) Curing. Cure each coat of paint according to the manufacturer's recommendations.

563.08 Structural Iron and Steel.

(a) Surface preparation.

(1) New surfaces or surfaces with existing paint removed. Remove dirt, mill scale, rust, and other foreign material from exposed surfaces by blast cleaning to near white metal according to SSPC-SP 10/NACE *No. 2 – Near-White Blast Cleaning*. Prepare surfaces inaccessible to near-white metal blast cleaning according to SSPC-*SP 11 – Power Tool Cleaning to Bare Metal*.

Use compressed air without oil or moisture when tested according to ASTM D4285. Do not use unwashed sand or abrasives that contain salts, dirt, oil, or other foreign matter. Protect machinery, sealed bearings, journals, motors, and moving parts against entry of abrasive dust.

Blast clean with clean dry slag, mineral grit, steel shot, or steel grit. Use a suitable gradation to produce a dense, uniform anchor pattern. Produce an anchor profile height of 1 to 2 mils (25 to 50 micrometers), but not less than that recommended by the paint system manufacturer's product data sheet. Measure anchor profile height according to ASTM D4417, Method C.

Remove dirt, dust, and other debris from the surface by vacuuming or other approved methods. Apply primer to bare metal surfaces within three days of cleaning. Repeat the blast cleaning if the cleaned surfaces rust or become contaminated before painting.

(2) Surfaces with existing sound paint. Do not remove sound paint unless specified. Protect adjacent areas of work from damage.

Clean visible oil, grease, and road tar according to SSPC *SP 1 – Solvent Cleaning*.

Prepare surfaces according to:

(a) NACE WJ-1/SSPC-*SP WJ-1 Waterjet Cleaning of Metals – Clean to Bare Substrate (WJ-1)*; or

(b) SSPC-SP 7/NACE *No. 4 – Brush-Off Blast Cleaning*.

Prepare surfaces inaccessible to water jetting or brush-off blasting according to SSPC-*SP 15 - Commercial Grade Power Tool Cleaning*.

(3) Surface with unsound paint. Perform spot abrasive blast cleaning according to SSPC-*SP 6 – Commercial Blast Cleaning*. Provide a sharp angular surface profile by an abrasive blasting procedure. Produce a minimum profile of 1 mil (25 micrometers) or the paint manufacturer's recommendation, whichever is greater.

Extend the prepared area at least 2 inches (50 millimeters) into adjacent tightly adhering, intact coating.

Feather edges of tightly adherent existing paint to produce a smooth appearance when repainting the surface.

Repeat solvent and surface cleaning if surfaces rust or become contaminated before painting.

Before painting, clean surfaces and staging areas with a vacuum or other approved methods.

(b) Paint application. Apply each coat to the wet film thickness as recommended by the paint manufacturer to obtain the specified dry film thickness. Verify the application rate of each coat with a wet film paint thickness gauge immediately after applying paint to the surface. Confirm the application rate by measuring the dry film thickness after the solvent has evaporated from the surface.

(1) New surfaces or surfaces with existing paint removed. Furnish a paint system shown in Table 563-1.

Table 563-1
Structural Iron and Steel Painting Systems for
New Surfaces or Surfaces with Existing Paint Removed

Paint System		Primer	Intermediate	Finish
1 (1)	**Aggressive Environments (Salt)**	Zinc-Rich paint (SSPC–Paint 20) 2.5 – 3.5 mils dry (65 – 90 µm dry)	Epoxy-Polyamide (SSPC–Paint 22) 2 – 3 mils dry (50 – 75 µm dry)	Aliphatic polyurethane (SSPC–Paint 36) 2 – 3 mils dry (50 – 75 µm dry)
2 (1)	**Aggressive Environments (Salt)**	Zinc-Rich Moisture-cured polyurethane (SSPC–Paint 40) 2 – 3 mils dry (50 – 75 µm dry)	Zinc-Rich Moisture-cured polyurethane (SSPC–Paint 40) 2 – 3 mils dry (50 – 75 µm dry)	Moisture-cured polyurethane (SSPC–Paint 38) 2 – 3 mils dry (50 – 75 µm dry)
3 (2)	**Less Aggressive Environments (No Salt)**	Latex primer (SSPC–Paint 23) 2 – 3 mils dry (50 – 75 µm dry)	Latex (SSPC–Paint 24) 2 – 3 mils dry (50 – 75 µm dry)	Latex (SSPC–Paint 24) 2 – 3 mils dry (50 – 75 µm dry)

(1) Paint Systems 1 or 2 are for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments (such as marine, industrial, high humidity, or structures exposed to deicing salts).

(2) Paint System 3 is for use in those environments without high concentrations of salts or pollutants that cause aggressive corrosion environments.

(2) Surfaces with existing sound paint. Furnish a paint system shown in Table 563-2.

Table 563-2
Structural Iron and Steel Painting Systems for Surfaces with Existing Sound Paint

Paint System		Primer [1]	Intermediate	Finish
4 [2]	**Aggressive Environments (Salt)**	Moisture-cured Polyurethane (SSPC–Paint 40 or 41) 2 – 3 mils dry (50 – 75 µm dry)	Moisture-cured Polyurethane (SSPC–Paint 41) 2 – 3 mils dry (50 – 75 µm dry))	Moisture-cured Aliphatic Polyurethane (SSPC–Paint 38) or Aliphatic Polyurethane (SSPC-Paint 36) 2 – 3 mils dry (50 – 75 µm dry)
5 [2]	**Aggressive Environments (Salt)**	Epoxy-Polyamide (SSPC–Paint 22) 3 – 4 mils dry (75 – 100 µm dry)	Epoxy-Polyamide (SSPC–Paint 22) 3 – 4 mils dry (75 – 100 µm dry)	Epoxy-Polyamide (SSPC–Paint 22) 3 – 4 mils dry (75 – 100 µm dry)
6 [3]	**Less Aggressive Environments (No Salt)**	Zinc Oxide, Alkyd, Linseed Oil Primer (SSPC–Paint 25, Type II) 2 – 3 mils dry (50 – 75 µm dry)	Alkyd (SSPC–Paint 104) 2 – 3 mils dry (50 – 75 µm dry)	Silicone Alkyd (SSPC–Paint 21, Type II) 2 – 3 mils dry (50 – 75 µm dry)

(1) Use primer only on areas where paint is removed to bare metal. Otherwise apply only intermediate and finish paints.

(2) Paint Systems 4 or 5 are for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments (such as marine, industrial, high humidity, or structures exposed to deicing salts).

(3) Paint System 6 is for use in those environments without high concentrations of salts or pollutants that cause aggressive corrosion environments.

Verify the compatibility of the proposed system with the existing system as follows:

(a) Select a test area of at least 30 square feet (3 square meters) in a condition representative of the condition of the structure. Perform the specified level of surface preparation, and apply the proposed system to the existing topcoat and to the existing primer. Perform tests according to ASTM D5064. Observe for lifting, bleeding, blistering, wrinkling, cracking, flaking, or other evidence of incompatibility.

(b) Verify that no indication of incompatibility exists at least 14 days after the application of each product. Perform adhesion tests according to ASTM D4541 self-aligning system.

Notify the CO if failure is due to adhesion (between coating and substrate or between applied coats) or cohesion (failure within a coating layer). If failure occurs, choose a more compatible paint system and repeat the compatibility process.

The dry paint thickness on steel structures will be determined using a Type 2 (electronic) film thickness gauge according to SSPC-*PA 2 – Measurement of Dry Coating Thickness with Magnetic Gages*, an ultrasonic coating thickness gage according to SSPC-*PA 9 - Measurement of Dry Coating Thickness on Cementitious Substrates*, or by using destructive methods according to ASTM D4138. If destructive methods are used, repair test locations in an approved manner.

563.09 Lumber and Timber. Dry timber to a moisture content of 15 percent or less.

Remove cracked or peeled paint, loose chalky paint, dirt, and other foreign material on previously painted timber. Use wire brushing, scraping, or other approved methods.

When timber is treated with a water borne preservative, wash and brush away visible salt crystals on the wood surface. Allow wood to dry before painting.

Remove dust or other foreign material from the surface just before painting.

Furnish a paint system shown in Table 563-3.

The primer may be applied before erection. Fill cracks, checks, nail holes, or other depressions flush with the surface using approved putty after the primer dries and the timber is in place. Evenly spread and thoroughly work the paint into corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the next coat.

Table 563-3
Paint for Other Structural Material

Substrate	Primer	Intermediate	Finish
Lumber & Timber (Dressed Surface)	Exterior Alkyd/Oil Wood Primer (MPI 5) 1 – 2 mils dry (60 – 70 µm dry)	Exterior Latex (MPI 5) or Alkyd/Oil (MPI 6) Wood Primer 1 – 2 mils dry (35 – 50 µm dry)	Exterior Latex (MPI 5) or Alkyd/Oil (MPI 6) Wood Primer 1 – 2 mils dry (35 – 50 µm dry)
Lumber & Timber (Rough Surface)	Exterior Latex (MPI 5) or Alkyd/Oil (MPI 6) Wood Primer 2 – 3 mils dry (35 – 50 µm dry)	Exterior Latex (MPI 5) or Alkyd/Oil (MPI 6) Wood Primer 1 – 2 mils dry (35 – 50 µm dry)	Exterior Latex (MPI 5) or Alkyd/Oil (MPI 6) Wood Primer 1 – 2 mils dry (35 – 50 µm dry)
Masonry Block	Exterior Latex Masonry Block Primer (MPI 4) 2 – 3 mils dry (60 – 70 µm dry)	Exterior Latex Flat (MPI 10) or Semi-Gloss (MPI 11) 1 – 2 mils dry (35 – 50 µm dry)	Exterior Latex Flat (MPI 10) or Semi-Gloss (MPI 11) 1 – 2 mils dry (35 – 50 µm dry)
Concrete	Epoxy Single Coat Low Gloss (MPI 108) or Semi-Gloss (MPI 177) 3 – 4 mils dry (80 – 100 µm dry).		
Aluminum	Metal Primer (MPI 95) 1 – 2 mils dry (35 – 50 µm dry)	Light Industrial Coating, Exterior, Water-Based (MPI 161, 163, or 164) 1 – 2 mils dry (35 – 50 µm dry)	Light Industrial Coating, Exterior, Water-Based (MPI 161, 163, or 164) 1 – 2 mils dry (35 – 50 µm dry)
Other Metals	Metal primer (1) 1 – 2 mils dry (35 – 50 µm dry)	Exterior Latex (MPI 5) or Alkyd/Oil (MPI 6) Wood Primer 1 – 2 mils dry (35 – 50 µm dry)	Exterior Latex (MPI 5) or Alkyd/Oil (MPI 6) Wood Primer 1 – 2 mils dry (35 – 50 µm dry)

(1) For galvanized surfaces, use a vinyl wash primer (SSPC–Paint 27), 0.3 to 0.5 mil (8 to 13 micrometers) dry thickness.

563.10 Masonry Block and Concrete Structures. Remove laitance, dust, or other deleterious material from the concrete surface. Give the cleaned surface a light abrasive sweep to remove mortar wash or other contaminants. Remove residue and dust by vacuuming or other approved methods.

Furnish a paint system shown in Table 563-3.

Evenly spread and thoroughly work the paint into corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the next coat.

563.11 Other Metals. Furnish the paint system shown in Table 563-3.

(a) Aluminum. Prepare aluminum surfaces to be painted according to ASTM D1730. Use the type of treatment and method of preparation appropriate to the condition of the surface and paint to be applied.

(b) Galvanized surfaces. Prepare galvanized surfaces to be painted according to ASTM D6386. Use the method of preparation appropriate to the condition of the surface to be painted (newly galvanized, partially weathered, or weathered galvanized steel).

563.12 Acceptance. Paint material will be evaluated under Subsections 106.02 and 106.03. Sample paint according to ASTM D3925. Test paint properties according to FED-STD 141D, *Paint, Varnish, Lacquer And Related Materials: Methods Of Inspection, Sampling And Testing* if required.

Surface preparation will be evaluated under Subsection 106.02.

Painting application will be evaluated under Subsections 106.02 and 106.04.

Measurement

563.13 Measure the Section 563 pay items listed in the bid schedule according to Subsection 109.02.

Payment

563.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 563 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 564. — BEARING DEVICES

Description

564.01 This work consists of furnishing and installing bridge bearings.

Bearing devices are designated as elastomeric, rocker, roller, and sliding plate.

Material

564.02 Conform to the following Section and Subsections:

Bearings (elastomeric, plain or laminated)	717.10(a)
Bolts and nuts (threaded anchor bolts)	717.01(d)
Galvanized coatings	717.07
Nonshrink grout	725.13(b)
Polytetrafluoroethylene (PTFE) surfaces for bearings	717.11
Steel Structures (rocker, roller, and sliding bearings)	555

Construction Requirements

564.03 General.

(a) Drawings. Submit drawings according to Subsection 104.03 and Section 18 of the AASHTO, *Load and Resistance Factor Design (LRFD) Bridge Construction Specification*. Show details of bearings including material proposed for use. Do not begin fabrication until drawings are approved by the CO.

(b) Fabrication. Fabricate bearings according to Section 18 of AASHTO, *LRFD Bridge Construction Specification*. Finish bearing components surfaces in contact with each other or with concrete, but not embedded in concrete according to Subsection 555.07(e).

Preassemble bearing assemblies and check for proper completeness and geometry. Galvanize steel bearing components and anchor bolts. Do not galvanize stainless steel bearing components or anchor bolts.

(c) Packaging, handling, and storing material. Clearly identify each bearing component and mark on its top the location and orientation in the structure before shipping. Securely bolt, strap, or otherwise fasten bearings to prevent relative movement.

Package bearings to prevent damage during shipping, handling or storing.

Do not dismantle bearing assemblies on-site unless necessary for inspection or installation. Dismantle under the direct supervision or with the approval of the manufacturer.

Furnish a listing of all individual bearing numbers.

Store bearing devices to prevent damage from weather or other hazards.

(d) Construction and installation. Clean bearings of deleterious material. Install and set bearings to the dimensions shown on the drawings or prescribed by the manufacturer. Adjust bearings according to the manufacturer's instructions to compensate for installation temperature and future movements.

Set bearings level, at the elevation, and position shown on the drawings. Provide full and even bearing on all external bearing contact surfaces. Notify the CO if bearing surfaces are at improper elevations, not level, or if bearings cannot be set properly. Submit a written proposal to modify the installation for approval.

Bed metallic bearing assemblies on concrete with an approved filler or fabric material when not embedded in concrete.

Set elastomeric bearing pads directly on properly prepared concrete surfaces without bedding material.

Machine bearing surfaces seated directly on steel to provide a level and planar bearing surface.

564.04 Elastomeric Bearings. Fabricate, comply with testing and acceptance criteria, and mark elastomeric bearings according to AASHTO M 251. Test and accept bearings specified by hardness and designed according to Method A of AASHTO, *Load and Resistance Factor Design (LRFD) Bridge Design Specifications* according to Appendix X1 of AASHTO M 251 instead of Section 8 full size bearing test.

Place bearings on a level surface. Correct misalignments in the support to form a level surface. Do not weld steel girders or base plates to the exterior plates of the bearing unless there is more than 1½ inches (38 millimeters) of steel between the weld and elastomer. Do not expose the elastomer or elastomer bond to instantaneous temperatures greater than 400 °F (200 °C).

564.05 Rocker, Roller, and Sliding Plate Bearings. Fabricate and finish rocker, roller, and sliding plate bearings according to Section 555. Remove burrs, rough and sharp edges, and other flaws. Stress relieve rocker, roller, and other bearings that are built up by welding sections of plate together before boring, straightening, or final machining.

Thoroughly coat contact surfaces with oil and graphite before placing roller bearings. Install rocker, roller, and sliding bearings vertically at the specified mean temperature after release of falsework and after shortening due to prestressing forces. Account for variations from mean temperature of the supported span at time of installation and other anticipated changes in length of the supported span.

Ensure the superstructure has full and free movement at movable bearings. Position cylindrical bearings so their axes of rotation align and coincide with the axis of rotation of the superstructure.

564.06 Masonry, Sole, and Shim Plates for Bearings. Provide metal plates conforming to AASHTO M 270, Grade 36 (250).

Fabricate and finish steel according to Section 555. Form holes in bearing plates by drilling, punching, or controlled oxygen cutting. Remove burrs by grinding.

Set bearing plates in a level position and provide a uniform bearing over the bearing contact area. When plates are embedded in concrete, make provisions to keep them in correct position as the concrete is placed.

564.07 Polytetrafluoroethylene (PTFE) Surfaces for Bearings. Furnish PTFE material that is factory-bonded, mechanically connected, or recessed into the backup material.

Bond or mechanically attach the fabric containing PTFE fibers to a rigid substrate. Use a fabric capable of carrying unit loads of 10,000 pounds per square inch (70 megapascals) without cold flow. Use a fabric-substrate bond capable of withstanding, a shear force equal to 10 percent of the perpendicular or normal application loading plus other bearing shear forces without delamination.

Use approved test methods and procedures according to Section 18 of AASHTO, *LRFD Bridge Construction Specification*. Perform at least one material test on the material used in the sliding surface for each lot of bearings. If required by the contract, test complete bearings for complete bearing friction. If the test facility does not permit testing of completed bearings; manufacture extra bearings and prepare samples of at least 100-kip (450-kilonewton) capacity at normal working stresses by sectioning the bearing.

Measure the coefficient of friction between two mating surfaces. Provide test results showing the static and dynamic coefficients of friction meet the requirements for the design coefficient of friction specified in the contract or by the manufacturer for approved material.

564.08 Anchor Bolts. Furnish threaded anchor bolts.

Adjust bolt locations for superstructure temperature and anticipated lengthening of bottom chord or bottom flange due to dead load after setting as required. Do not restrict free movement of the superstructure at movable bearings.

Preset anchor bolts before concrete placement or install anchor bolts in drilled holes after concrete placement. Drill holes 1 inch (25 millimeters) in diameter greater than the bolt if nonshrink cement grout is used to secure the bolts. Follow adhesive manufacturer’s recommendations for hole-diameter if an approved chemical adhesive is used to secure the bolts.

564.09 Bedding of Masonry Plates. Clean the contact surfaces of the concrete and steel before placing the bedding material and installing bearings or masonry plates. If bedding is specified, place filler or fabric as bedding material under masonry plates and install it to provide full bearing on contact areas. If bedding material is not specified, comply with Subsection 18.10.2 of AASHTO, *LRFD Bridge Construction Specifications* as directed by the CO.

564.10 Acceptance. Bearing devices will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of bearing devices.

Bearing device installation will be evaluated under Subsections 106.02 and 106.04.

Measurement

564.11 Measure the Section 564 pay items listed in the bid schedule according to Subsection 109.02.

Payment

564.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 564 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 565. — DRILLED SHAFTS

Description

565.01 This work consists of furnishing and constructing reinforced concrete drilled shafts.

Material

565.02 Conform to the following Section and Subsections:

Neat hydraulic cement grout	725.13(a)(2)
Reinforcing steel	709.01
Slurry (Drilling fluids)	725.16
Structural carbon steel (Casings)	717.01(a)
Structural concrete	552
Water	725.01(a)

Construction Requirements

565.03 Qualifications. Provide a crosshole sonic logging engineer, on-site supervisors, and installation personnel with experience installing and testing drilled shafts. Submit the following for approval at least 30 days before starting work:

(a) Names of personnel; and

(b) A résumé for each individual describing their experience on at least 5 drilled shaft projects of similar complexity over the past 5 years. Include project names, locations, and contact information for project owners.

565.04 Construction Plan. At least 30 days before starting drilled shaft work, submit the following according to Subsection 104.03:

(a) Proposed drilled shaft construction schedule and sequence. Schedule shaft installation to avoid interconnection or damage to shafts in which placed concrete has not achieved final set.

(b) Proposed drilling, hole cleaning/preparation, and reinforcement/concrete placement equipment and procedures for the ground conditions expected to be encountered. Provide specific shaft drilling and concreting procedures to mitigate problems associated with ground water, surface water bodies, or both. Demonstrate an understanding of the subsurface conditions at the site by referencing available subsurface data provided in the contract boring logs. Indicate procedures to minimize disturbance to the construction site or overlaying or adjacent structure or services. Discuss potential drilling difficulties and indicate methods and tooling that will be used to remove obstructions from the excavation.

(c) Proposed drilled shaft excavation and construction methods used to ensure shaft stability during construction and reinforcement/concrete placement. Include proposed shaft drilling procedures for maintaining required horizontal and vertical shaft alignment and a disposal plan for excavated material. If shaft casing is required, provide casing dimensions and detailed procedures for permanent casing installation or temporary casing installation and removal.

(d) Proposed methods for mixing, testing, circulating, using, maintaining, and disposing of slurry, if used. Provide a detailed slurry mix design and its suitability to the subsurface conditions.

(e) Details of reinforcement placement including bracing, centering, centralizers, and lifting and support methods.

(f) Proposed structural concrete mix design according to Subsection 565.08.

(g) Concrete placement methods including proposed operational procedures for free-fall, tremie, or pumping methods.

(h) The method used to form an emergency horizontal construction joint during concrete placement.

Specific guidance on installation of and construction plan requirements for drilled shafts can be found in FHWA-NHI-10-016, *Drilled Shafts: Construction Procedures and LRFD Design Methods*.

565.05 Trial Drilled Shafts. When trial drilled shafts are required, perform the work according to the applicable requirements of Subsection 565.06.

Before drilling holes for production shafts, demonstrate that the proposed methods and equipment are adequate by drilling a trial drilled shaft adjacent to the production shafts at a location approved by the CO. Make the center-to-center spacing between the trial shaft and production shafts at least three shaft diameters or two bell diameters, whichever is larger.

Construct the trial drilled shaft to the same size and to the tip elevation of the deepest production shaft shown in the plans. When bells are specified for production shafts, include a bell in the final trial shaft to verify the feasibility of belling in the specified bearing stratum.

Install casing if caving occurs or the hole deforms sufficient to encroach upon the planned placement of the reinforcement cage with specified minimum concrete cover. Seat the casing to prevent caving and to allow dewatering of the hole when required. Remove material from inside the hole. Keep casing in place at least 4 hours while attempting to remove all water in the hole. Record the rate of groundwater seepage into the hole. After this 4 hour period, fill the hole with saturated sand while the casing is removed to simulate the concreting operation and casing removal for the production drilled shafts.

Concrete or reinforcing steel is not required in the trial drilled shaft.

Modify methods and equipment if the trial drilled shaft does not meet performance requirements as determined by the CO. Submit a new installation plan and drill a new trial shaft for approval.

565.06 Shaft Drilling.

(a) Drilling. Drill holes according to the approved installation plan. Excavate structural footings supported on drilled shafts and construct fills before initiating shaft drilling.

Provide equipment and tooling with the capability to drill shafts of the specified diameter and lengths 20 percent longer than those specified. Position the drilled shaft within 3 inches (75 millimeters) of the required position in a horizontal plane at the top-of-shaft elevation. Do not allow the constructed alignment of a vertical shaft to vary from the required alignment by more than ¼ inch per 12 inches (6 millimeters per 300 millimeters) of hole depth.

(1) Boring log. Use a geologist or an engineer to maintain a boring log of material excavated from the drilled shaft. Include the following information:

(a) Description and approximate top and bottom elevation of each type of soil or rock material encountered and the date and time the soil or rock material was encountered;

(b) Elevation and approximate rate of seepage or groundwater encountered;

(c) Equipment used to drill the shaft, time required to complete the shaft, bit changes, breakdowns, and other drilling difficulties encountered; and

(d) Remarks.

(2) Drilling methods. Use the uncased dry construction method where groundwater level and soil conditions are suitable to construct the shaft in a relatively dry-stable excavation and may be visually inspected before placing concrete. Use casing, wet construction method, or both for shafts that do not meet the requirements for the dry construction method.

(a) Dry method. This method consists of drilling the shaft, removing accumulated water and loose material from the excavation, placing the reinforcing cage, and concreting the shaft in a relatively dry excavation.

The dry construction method can only be used when the excavation meets the following:

(1) Less than 12 inches (300 millimeters) of water accumulates above the base of the hole during a 1-hour period when no pumping is permitted;

(2) The sides and bottom of the hole remain stable without detrimental caving, sloughing, or swelling over a 4-hour period immediately following completion of the excavation or over-reaming when approved by CO; and

(3) Loose material and water can be satisfactorily removed before inspection and before reinforcement and concrete placement.

(b) Wet method. This method consists of using water or slurry to maintain shaft stability while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft. In addition, perform the following:

(1) Desanding and cleaning drilling slurry;

(2) Final cleaning of the excavation using a bailing bucket, air lift, submersible pump, or other approved devices; and

(3) Placing shaft concrete with a tremie or concrete pump, beginning at the shaft bottom.

Maintain the drilled hole to the specified nominal diameter before placing reinforcement elements and concrete. Increase the hole diameter at least ½ inch (13 millimeters) to a maximum of 3 inches (75 millimeters) when approved by the CO if ground softening, swelling or slurry cake buildup occurs. Case the hole, use a slurry during drilling, or both if the drilled hole continues to degrade and encroach upon the planned placement of the reinforcement cage with specified minimum concrete cover.

Extend exterior casings from above the waterline to a subsurface elevation to protect against water action during placement and curing of the concrete when drilled shafts are located in open waters. Install the exterior casing in a manner that will provide a positive seal at the bottom of the casing to prevent piping of water or entry of other material from the shaft excavation behind the casing.

Remove drill cuttings, other loose debris, or both from the bottom of the hole upon completion of drilling. Clean the drilled hole leaving no more than ½ inch (13 millimeters) of sediment on the bottom of the hole. Reduce the depth of accumulated water to 3 inches (75 millimeters) or less before placing concrete in shafts constructed using the dry method.

Do not drill additional shafts, allow wheel loads, vibration-inducing equipment, or other construction activities within 15 feet (4.5 meters) or 3 shaft diameters, whichever is greater, of a newly constructed shaft for at least 20 hours.

Fill rejected drill holes with lean concrete.

(b) Slurry. Premix slurry with potable water according to the slurry manufacturer's instructions to allow for hydration before introduction into the shaft excavation. Use slurry tanks of adequate capacity for slurry circulation, storage, and treatment. Do not use excavated slurry pits or the shaft excavation to mix the slurry. Do not add slurry component directly into the shaft excavation.

Provide desanding equipment to limit slurry sand content as specified in Tables 565-1 and 565-2, at any point within the shaft. Verify sand content immediately before placing concrete. Desanding is not required for setting temporary casings, sign posts, or lighting mast foundations.

Maintain the level of slurry in the excavation at least 5 feet (1.5 meters) above the highest expected adjacent piezometric water pressure head for mineral slurry, or 10 feet (3 meters) above the highest expected piezometric water pressure head for polymer or water slurry.

Stop drilling and take corrective measures when there is a sudden loss of slurry from the hole. Prevent the slurry from setting up in the shaft. Discontinue the use of slurry and use an approved alternative method if the slurry construction method fails to produce the desired results.

Maintain density, viscosity, and pH of the mineral or polymer slurry throughout shaft excavation and concrete placement according to Tables 565-1 and 565-2. Take slurry samples using an approved sampling tool. Extract slurry samples from the base of the shaft and 10 feet (3 meters) up from the base of the shaft. Perform 4 sets of tests during the first 8 hours of slurry use. The testing frequency may be decreased to one test set for every 4 hours of slurry use when results are acceptable and consistent.

Table 565-1
Acceptable Range of Values for Mineral Slurry

Property	In Hole at Time of Test Concreting	Method
Density[(1)] pounds per cubic foot (kilograms per cubic meter)	64 – 72 (1025 – 1153)	Density balance API 13B-1[(2)], Section 1
Viscosity seconds per quart (seconds per liter)	28 – 50 (30 – 53)	Marsh Funnel AP 13B-1[(2)], Section 2.2
pH	8 – 11	pH paper or meter
Sand content, %	4.0 max.	API 13B-1[(2)], Section 5

(1) Density values shown are for fresh water. Increase density values 2 pounds per cubic foot (23 kilograms per cubic meter) for saltwater. Perform tests when slurry temperature is above 40°F (4.5 °C).

(2) American Petroleum Institute, API 13B-1, *Recommended Practice for Field Testing Water-based Drilling Fluids*.

Comply with manufacturer's recommendations and Table 565-2 test requirements for polymer slurry. Submit the name and telephone number of the manufacturer's representative to the CO.

Table 565-2
Acceptable Range of Values for Polymer Slurry

Property	In Hole at Time of Test Concreting	Method
Density[(1)] pounds per cubic foot (kilograms per cubic meter)	64 max. (1025 max.)	Density balance API 13B-1[(2)], Section 1
Viscosity seconds per quart (seconds per liter)	32 – 135 (34 – 143)	Marsh Funnel AP 13B-1[(2)], Section 2.2
pH	8 – 11	pH paper or meter
Sand content, %	1.0 max.	API 13B-1[(2)], Section 5

(1) Density values shown are for fresh water. Increase density values 2 pounds per cubic foot (23 kilograms per cubic meter) for saltwater. Perform tests when slurry temperature is above 40 °F (4.5 °C).

(2) See note (2) in Table 565-1.

Correct slurry when sample do not meet the requirements of Tables 565-1 or 565-2. Do not place concrete until the results of the resampling and retesting are approved.

(c) Casings. Install temporary casing to prevent sloughing of the top of the shaft excavation, unless it can be satisfactorily demonstrated to the CO that surface casing is not required. Install temporary casing regardless of excavation method when sidewall conditions warrant additional stabilization or mitigation of excessive groundwater infiltration.

Use smooth, clean, watertight, steel casings of sufficient strength to withstand handling, installation stresses, concrete placement, and surrounding earth pressures. Casing diameters are outside diameters when shown in the plans. The diameter of a permanent casing is subject to American Petroleum Institute tolerances applicable to regular steel pipe. Make the outside diameter of the casing no less than the specified size of the shaft.

Install casings to produce a positive seal at the bottom of the shaft to prevent piping of water or other material into or out of the excavated hole. Stabilize the excavation with slurry, backfill, or other methods approved by the CO if it becomes necessary to remove a casing. Maintain an adequate head of water or slurry inside the casing to prevent piping or sloughing of material at the bottom of the hole when drilling below the water table.

Subsurface casings are to be considered temporary unless designated as permanent casing. Remove temporary casing concurrent with concrete placement. Maintain the concrete within the casing so fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete.

Temporary casings that have become bound or fouled during shaft construction and cannot be practically removed are considered to be a defect in the drilled shaft. Correct defective shafts using methods approved by the CO. Corrective action may consist of, but is not limited to, the following:

(1) Removing the shaft concrete and extending the shaft deeper to compensate for loss of frictional capacity in the cased zone;

(2) Providing straddle shafts to compensate for capacity loss; or

(3) Providing a replacement shaft.

Cut permanent casing off at the required elevation and leave in place

565.07 Reinforcing Steel and Crosshole Sonic Logging (CSL) Access Tubes Placement. Perform reinforcing steel work according to Section 554. Securely wire together contact reinforcing steel lap splices. Tie and support the reinforcing steel so it remains within the required tolerances. Securely tie concrete spacers or other approved spacing devices at fifth points around the cage perimeter and space at intervals not to exceed 10 feet (3 meters) along the length of the cage. Use spacers of approved material at least equal in quality and durability to the shaft concrete.

Install steel CSL access tubes for each drilled shaft at locations specified and according to ASTM D6760. Extend access tubes at least 24 inches (600 millimeters) above shaft top and a maximum of 3 inches (75 millimeters) above shaft bottom. Use 1½ inch (38 millimeters) nominal diameter Schedule 40 mild steel standard black pipe conforming to ASTM A53, any grade, Type E, Type F or Type S, for CSL access tubes. Provide a watertight end plug at the lower end of the pipe and make joints watertight. Fill the CSL access tubes with potable water before placing concrete in the drilled shaft. Temporarily cap the top of the tubes to prevent debris or concrete from entering the tubes.

Place the reinforcing steel cage as a unit immediately after the drilled hole is inspected, accepted, and before concrete placement. Remove cage when directed by the CO for re-inspection if concrete is not placed immediately. Handle reinforcing cages in a manner to avoid distortion or racking of the steel.

Provide positive support at the top for the reinforcing steel cage during concrete placement. Maintain the top of the reinforcing steel cage no more than 6 inches (150 millimeters) above and no more than 3 inches (75 millimeters) below the required elevation. Make acceptable corrections if the reinforcing steel cage is not maintained within tolerances. Do not construct additional shafts until the method of reinforcing steel cage support has been approved.

Do not proceed with installation of subsequent shafts until CSL testing has been completed on the first drilled shaft and the results have been approved in writing by the CO. Approval to proceed with the construction of subsequent shafts, before receiving approval of the first shaft will be based on observations of workmanship during construction of the first shaft and the following:

(a) Contractor's conformance with the approved shaft installation plan;

(b) Contractor's daily reports and inspector's daily logs of excavation, rebar, and concrete placement; and

(c) Concrete placement logs and volume curves.

The CO will provide written notification to proceed with subsequent shaft construction within 24 hours after completion of the first shaft. If the CO determines the first shaft to be of questionable quality, discontinue all shaft construction until the CSL test results of the first shaft are received and reviewed and the shaft accepted in writing by the CO.

After the first drilled shaft has been accepted, do not change construction methods, equipment, or material used to construct subsequent shafts, unless otherwise approved.

565.08 Concrete for Drilled Shafts. Use a removable form or other approved means to form the shaft to at least 24 inches (600 millimeters) below finished ground when the top of shaft is above ground. Forms may be removed provided the requirements in Subsection 562.07 are complied with and the shaft concrete has not been exposed to saltwater or moving water for 7 days. Strip the forms without damaging the concrete.

Remove the top portion of the drilled shaft concrete before continuing with column construction when it is determined the concrete has been affected by underwater placement.

Place concrete immediately after excavation is complete and the reinforcing steel cage with CSL access tubes is in place.

Furnish concrete conforming to Section 552, except:

- Class A structural concrete having a slump of 7±1 inches (180±25 millimeters) for shafts constructed without drilling fluid;
- Class A structural concrete having a slump of 8±1 inches (200±25 millimeters) for shafts constructed with drilling fluid; and
- Class S concrete for under water placement.

Do not use seal concrete above the freeze-thaw or wet-dry zone of the hole. Place underwater concrete according to Subsection 552.11(e), except as modified in this Section. The method of underwater placement is subject to CO approval.

Adjust approved admixtures for project conditions to ensure that the concrete has the minimum required slump for at least 2 hours. Submit trial mix and slump loss test results for concrete at ambient temperatures appropriate for site conditions.

Place each load of concrete within 2 hours of batching. Longer placement time may be permitted if the concrete mix maintains the minimum required slump for longer than 2 hours. Do not retemper concrete that has developed its initial set.

Place concrete in one continuous operation from bottom to top of the shaft.

Continue placing concrete after the shaft excavation is full and until acceptable quality concrete is evident at the top of shaft. Consolidate the top 10 feet (3 meters) of the shaft concrete using acceptable vibratory equipment before initial concrete set. Finish the top of the shaft to within plus 1 to minus 3 inches (plus 25 to minus 75 millimeters) of the required elevation. Do not consolidate shaft concrete until water or slurry above the finish concrete level has been removed.

Place concrete using the following methods:

(a) Free-fall. Use free-fall placement only in dry holes. Ensure the concrete falls directly to the shaft base without contacting either the rebar cage or shaft sidewall.

Drop chutes may be used to direct placement of free-fall concrete. Drop chutes consist of a smooth tube of either one-piece construction or sections that can be added and removed. Support the drop chute so that the maximum height of free-fall of the concrete measured from the bottom of the chute is 25 feet (8 meters). Reduce the height of free-fall or rate of concrete flow into the excavation if concrete placement causes the shaft excavation to cave or slough, strikes the rebar cage or sidewall. Use tremie or pumping to place the concrete if placement cannot be satisfactorily accomplished by free-fall placement.

(b) Tremies. Use tremies for concrete placement in either wet or dry holes. A tremie consists of a hopper and tube of sufficient length, mass, and diameter to discharge concrete at the shaft base. Do not use tremies that contain aluminum parts that will come in contact with the concrete. Furnish a tremie tube with clean and smooth inside and outside surfaces and sufficient wall thickness to prevent crimping or sharp bends. Provide tubes with an inside diameter at least six times the maximum size of aggregate used in the concrete mix, but not less than 10 inches (250 millimeters). Use a watertight tremie according to Subsection 552.11(e) for wet holes. Construct the discharge end of the tremie to permit free radial flow of concrete during placement. Place the tremie discharge at the shaft base elevation. Place the concrete in a continuous flow. Keep the tremie discharge immersed at least 10 feet (3 meters) below the surface of the fluid concrete. Maintain a positive head of concrete in the tremie at all times. If the tremie discharge is removed from the fluid concrete column and discharges concrete above the rising concrete surface into displaced water; remove the reinforcing cage and concrete, complete necessary sidewall removal as directed, and reconstruct the shaft.

(c) Pumps. Use pumped concrete placement in either wet or dry holes. Use a 4-inch (100-millimeter) minimum diameter discharge tube with watertight joints. Place the discharge tube at the shaft base elevation.

Use a sealed discharge tube according to Subsection 552.11(e) for wet holes. If a plug is used, remove it from the hole or use a plug made from approved material that will prevent a defect in the shaft if not removed.

Place the concrete in a continuous flow. Keep the pump discharge tube immersed at least 10 feet (1.5 meters) below the surface of the fluid concrete. Remove the reinforcing cage and concrete if the discharge tube is removed from the fluid concrete column and discharges concrete into displaced water. Complete necessary sidewall removal as directed by the CO, and reconstruct the shaft.

565.09 Integrity Testing.

(a) Testing. Perform integrity testing on all production drilled shafts according to ASTM D6760. Test drilled shafts between 2 and 21 days after concrete placement. Furnish drilled shaft bottom and tip elevations, access tube lengths, surveyed tube positions, and date of concrete placement before testing to the CSL subcontractor and the CO. Perform tests between all tube pairings in the shaft, including adjacent perimeter access tubes and diagonally between tubes.

If an access tube is unacceptable for testing (such as tube is not plumb, tube does not retain water, tube is obstructed, tube-concrete debonding has occurred); drill a plumb core hole to the appropriate depth and install a fully-grouted replacement tube or propose an alternative integrity test method that is acceptable to the CO.

Tremie fill access tubes with neat hydraulic cement grout after integrity testing, inspection and data analysis are completed and accepted by the CO.

(b) Test results and reporting. Submit preliminary results for each shaft tested before CSL test personnel leave the site. Submit a detailed CSL report to the CO within 5 days of testing. Allow 5 days for the CO to conduct a review of the data before continuing construction on the tested shaft and before issuing the final written report. Include the following in the CSL report:

(1) Project identification and dates of CSL testing;

(2) Table and a schematic showing shafts tested with identification of tube coordinates and collar elevation;

(3) Names of personnel that performed the CSL tests and interpretations and their affiliations;

(4) Type of equipment used for testing;

(5) Data logs and waterfall diagrams;

(6) X-Y plots of first arrival times, amplitude, and velocity versus shaft depth; and

(7) Interpretations, analyses, and results.

Identify and provide detailed discussion of each anomalous zone detected by the CSL. Anomalous zones are areas where velocity reduction exceeds 20 percent of the average velocity of properly placed and cured shaft concrete at the time of testing. Collect and process additional data sufficient to construct three-dimensional color-coded tomographic-images with two-dimensional cross-sections between tubes within anomalous zones.

565.10 Acceptance.

(a) Material for drilled shafts will be evaluated as follows:

(1) Slurries will be evaluated under Subsections 106.02 and 106.03.

(2) Concrete will be evaluated under Section 552. Concrete, tremie placed or pumped, will be sampled at point of discharge into the tremie or concrete pump hopper.

(3) Reinforcing steel will be evaluated under Section 554.

(b) Construction of drilled shafts will be evaluated under Subsections 106.02, 106.03, and 106.04 as follows:

(1) Drilled shafts exhibiting velocity reductions less than or equal to 20 percent of the average velocity of properly placed and cured shaft concrete at the time of testing are acceptable.

(2) Where velocity reductions exceed 20 percent of the average velocity of properly placed and cured shaft concrete at the time of testing, furnish additional imaging and other data required in Subsection 565.09(b) to enable further evaluation of the shaft. Drill at least two core holes to intercept the anomalous zone and obtain core samples from the suspect area when required by the CO. The CO will evaluate the crosshole sonic logging data, the tomographic imaging data, and the retrieved core data and make a determination as to the presence of substantive defects.

Remove and replace rejected shafts or propose alternatives according to Subsection 106.01. Submit design modifications to drilled shafts or load transfer mechanisms, foundation elements, and drawings according to Subsection 104.03(b)(2). Do not begin remedial work until drawings have been approved by the CO.

Measurement

565.11 Measure the Section 565 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure drilled shafts from the plan top elevation to the approved tip. Do not measure portions of shafts extending deeper than approved.

Measure trial drilled shafts, determined to be satisfactory, from the approved tip elevation to the ground surface at the center of the shaft.

Do not measure concrete or reinforcing steel.

Payment

565.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 565 pay items listed in the bid schedule, except the drilled shaft contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for drilled shafts will be made at a price determined by multiplying the contract price by the structural concrete compressive strength pay factor.

Section 566. — SHOTCRETE

Description

566.01 This work consists of constructing one or more courses of shotcrete on a prepared surface.

Shotcrete aggregate grading is designated according to Table 703-11.

Material

566.02 Conform to the following Subsections:

Air-entraining admixtures (wet mix only)	711.02
Anchorage devices	722.01
Chemical admixtures (wet mix only)	711.03
Concrete coloring agents	711.05
Curing material	711.01
Hydraulic cement	701.01
Penetrating stain	719.08
Pozzolans	725.04
Reinforcing fibers	725.17
Reinforcing steel	709.01
Shotcrete aggregate	703.16
Steel welded wire reinforcement, plain, for concrete	709.01(h)
Water	725.01(a)
Welded deformed steel wire fabric	709.01(j)

Construction Requirements

566.03 Qualifications. Submit the following for approval at least 30 days before shotcrete operations begin:

(a) Foreman. Name and a résumé describing experience in shotcrete construction on at least five projects of similar complexity.

(b) Nozzle operator. Name and a résumé describing experience in shotcrete construction. Provide a ACI nozzle operator certification for the orientations in which shotcrete will be applied and of having completed at least one similar application as a nozzle operator on a project of similar complexity.

566.04 Composition (Shotcrete Mix Design). Design and produce shotcrete mixtures that conform to Table 566-1 and ACI 506.02, *Specification for Shotcrete*.

Verify mix design with trial mixes prepared from the same source proposed for use. Submit the following for approval at least 30 days before placing shotcrete:

(a) Proposed shotcrete mix design with mix proportions and aggregate grading. When applicable, include air content, dosage, and type of admixture;

(b) Representative samples of shotcrete material, if requested by the CO. Results of shotcrete preconstruction testing demonstrating compliance with Table 566-1;

(c) Proposed method for applying shotcrete;

(d) Other information necessary to verify compliance with ACI 506.2;

(e) Shotcrete material certifications;

(f) Fiber samples, if used; and

(g) Description of proposed equipment for mixing and applying shotcrete. Include the manufacturer's instructions, recommendations, literature, performance and test data. In addition, conform to the equipment requirements in ACI 506, *Guide to Shotcrete* and include the following:

(1) Water supply system. For dry mix, provide a job site water storage tank. Provide a positive displacement pump with a regulating valve that is accurately controlled to provide water at the required pressure and volume.

(2) Mixing. Use equipment capable of handling and applying shotcrete containing the specified maximum size aggregate and admixtures. Provide an air hose and blow pipe to clear dust and rebound during shotcrete application.

566.05 Hydration Stabilizing Admixtures. When hydration stabilizing admixtures are used, include admixtures in the shotcrete mix design. Base dosage on the time needed to delay the initial set of the shotcrete for delivery and discharge on the job. Include the design discharge time limit in the dosage submittal. The maximum allowable design discharge time is 3½ hours.

Use an approved and compatible hydration activator at the discharge site to ensure proper placement and testing.

Determine dosage required to stabilize shotcrete using job site material and field trial mixtures. The extended-set admixture will control the hydration of cement minerals and gypsum.

When requested, provide the service of a qualified person from the admixture manufacturer to assist in establishing the proper dose of extended-set admixture and to make dosage adjustments required to meet changing job site conditions.

Table 566-1[8]
Composition and Property Requirements of Shotcrete Mixtures

Type of Shotcrete Process	Minimum Cement Content lb/yd^3 (kg/m^3)	Maximum Water-Cementitious Material Ratio	Air Content	Minimum 28-Day Compressive Strength, f'c psi (MPa) [2] [3]	Maximum Boiling Absorption [2][4] (%)	Maximum Permeable Void Volume [2] [4] (%)	Maximum Mean Core Grade [2] [5] [7]	Maximum Water-Soluble Chloride Ion (Cl^-) Content (% by Mass of Cement) [2] [6] [7]
Wet	658 (390)	0.50	–	4000 (28)	9	17	2.5	0.15
Wet (AE)	658 (390)	0.45	Grading A 7 %[1] Grading B 6%[1]	4000 (28)	9	17	2.5	0.15
Dry	658 (390)	0.40	–	4000 (28)	9	17	2.5	0.15

(1) Sample according to ASTM C1385. Measure air content on composite samples that have been acquired from material delivered to the shotcrete machine before pumping according to AASHTO T 152 or AASHTO T 196. A tolerance of ±1.5 percent is allowed. A minimum in-place shotcrete air content of 4 percent is required after shooting.

(2) Prepare and cure test panels according to Subsection 566.06(a)(1). Drill 3-inch (75-millimeter) diameter cores according to Subsection 566.06(a)(2).

(3) Conduct and report compressive strength tests according to Subsection 566.06(a)(3). Calculate mean compressive core strength as the average strength of at least three individual cores, taken from the same nonreinforced test panel. Every arithmetic average of any three consecutive mean core strengths must equal or exceed 0.85 f'c with no individual core less than 0.75 f'c.

(4) Perform and report coating quality tests according to Subsection 566.06(a)(3). No individual test may be greater than the maximum specified.

(5) When shotcrete is applied over reinforcement, conduct and report core grading according to Subsection 566.06(a)(3). Calculate mean core grade as the average of at least three individual core grades, taken from the same reinforced test panel. The mean core grade must not be greater than the maximum mean core grade with no individual core grade greater than 3.

(6) When shotcrete is applied over reinforcement, perform and report water-soluble chloride ion (Cl^-) content testing according to Subsection 566.06(a)(3). No individual test may be greater than the maximum specified.

(7) Perform during preconstruction testing only.

(8) Produce a mix with a cement to aggregate ratio, based on dry loose volumes, of not less than 1 to 3.5 for the construction and repair of concrete structures and for encasing steel members, and not less than 1 to 5 for lining ditches and channels and for paving slopes. Use a water content as low as practical so that mix is sufficiently wet to adhere properly and sufficiently dry so that it will not sag or fall from vertical or inclined surfaces or separate in horizontal work.

566.06 Preconstruction Testing.

(a) Field trials. Conduct preconstruction shotcrete field trials before starting shotcrete production.

(1) Test panels. Prepare and cure test panels according to ASTM C1140. Construct steel or wood test panel forms containing no reinforcement with a minimum width and length of 24 inches (600 millimeters) and a minimum depth of 6 inches (150 millimeters) with either square or sloped sides.

When shotcrete is to be applied over reinforcement, construct additional steel or wood test panel forms containing reinforcement with a minimum width and length of 30 inches (750 millimeters) and a minimum depth of 3 inches (75 millimeters) with either square or sloped sides. Use reinforcement of the same size and spacing required for the project.

Shoot test panels using the personnel, material, equipment, operating pressures, and mix designs proposed for the project. Produce test panels for each proposed mix proportion, each anticipated shooting orientation, and each proposed nozzle operator.

As soon after shooting and is safe to prevent damage, cover and tightly wrap the panels with material conforming to ASTM C171 or store the panels in a moist room conforming to AASHTO M 201.

(2) Coring. At least 14 days after shooting, drill at least three 3-inch (75-millimeters) diameter cores from each test panel according to AASHTO T 24. Moisture condition the cores in sealed plastic bags or nonabsorbent containers according to Section 7.3 of AASHTO T 24. Deliver Government cores to the laboratory designated by the CO.

(3) Testing. At least 14 days, but no later than 28 days after shooting; perform and report coating quality tests including density, boiling absorption and volume of permeable voids according to ASTM C642. Test at least three samples from each nonreinforced test panel. Samples may consist of cores or pieces of cores or test panels that are without observable cracks, fissures, or shattered edges.

Before compressive strength testing, saw or tool the ends of the cores to eliminate projections and to achieve perpendicularity to the longitudinal axis. At 28 days after shooting, conduct and report compressive strength tests according to AASHTO T 24. Test at least three cores from each nonreinforced test panel.

When shotcrete is applied over reinforcement, visually grade at least three cores from each reinforced test panel according to Section 1.7 of ACI 506.2 at least 14 days, but no later than 28 days after shooting. Between 28 and 48 days, determine the maximum water-soluble chloride-ion concentration on at least three different test panel samples according to ASTM C1218.

(4) Mix design approval. Submit the test data and results as well as a visual description of each core to the CO. Include details concerning presence of voids, sand pockets, lamination, and other inadequacies. Approval of the nozzle operator and mix design will be based on preconstruction field trials and test results. The test results must meet the requirements of Table 566-1 including the following:

(a) Compressive strength tests. Calculate the mean compressive core strength of at least three individual, 3-inch (75-millimeter) diameter cores, taken from the same test panel. The mean of any three consecutive core strengths must equal or exceed 0.85 f’c with no individual core less than 0.75 f’c.

(b) Coating quality tests. Calculate density, boiling absorption, and volume of permeable voids for each test sample. No individual test may be greater than the maximum permissible values shown in Table 566-1.

(c) Core grading tests. Calculate the mean core grade from at least three individual core grades. The mean core grade must not be greater than the maximum permissible value shown in Table 566-1 with no individual core grade greater than 3. When a prequalification test panel is rejected by the CO, a second panel may be shot. If the nozzle operator's second mean core grade is greater than 2.5, that nozzle operator is not permitted to shoot shotcrete on the project. Core grading is performed during preconstruction testing only as a way of prequalifying nozzle operators.

(d) Water-soluble chloride ion concentration tests. Calculate the water-soluble chloride ion concentration for each test sample. No individual test may be greater than the maximum permissible values shown in Table 566-1. Water-soluble chloride ion analysis is performed during preconstruction testing only as a way of ensuring corrosion protection of the reinforcement.

(b) Submissions. Submit field quality control test reports with the test data and results. Include the following information in the reports:

(1) Date and time of test panel shooting including panel dimensions, size and spacing of reinforcement, when used, and type of curing;

(2) Test panel identification including panel number, shooting orientation, mix proportions and nozzle operator;

(3) Date, time, method of panel coring, number of test samples obtained from each panel and sample preparation methods;

(4) Test sample identification by panel number, sample number and sample dimensions; and

(5) Date, time and types of tests performed.

566.07 Shotcrete Construction. Produce shotcrete according to ACI 506.2 and the following:

(a) Surface preparation. When shotcrete is to be placed over existing concrete or rock, remove loose or deteriorated material from the existing surface by chipping with pneumatic or hand tools. Cut shoulders approximately 1 inch (25 millimeters) deep along the perimeter of repair areas on existing concrete.

Remove curing compound on previously-placed shotcrete surfaces by sandblasting or other approved method. Maintain prepared surfaces in a clean and dry condition. Install approved depth gauges to indicate the thickness of the shotcrete layers. Install depth gauges on 6-foot (1.8-meter) centers longitudinally and transversely with no less than two gauges per increment of surface area to receive the shotcrete.

Moisten surfaces. When applying shotcrete to previously-placed shotcrete or concrete, provide a saturated surface dry condition. Soak surfaces with water 2 to 24 hours before application. Immediately before shotcreting, blow the surfaces free of water.

When applying shotcrete to soil, thoroughly compact the soil to provide a firm foundation. Ensure the soil lack free surface water before placing shotcrete.

(b) Reinforcing. Install reinforcing steel when required. Support reinforcing steel so it is not displaced during shotcrete application. Support the reinforcing steel by anchor studs or bolts installed in the existing surface. Space anchors at no more than 12 inches (300 millimeters) on overhead surfaces, 18 inches (450 millimeters) on vertical surfaces, and 36 inches (900 millimeters) on top horizontal surfaces. Use at least three anchors in each individual area. Reinforce areas where shotcrete thickness exceeds 1½ inches (38 millimeters) with a single layer of either 2 by 2 – W1.2 by W1.2 or 3 by 3 - W1.5 by W1.5 (50 by 50 – MW8 by W8 or 75 by 75 – MW10 by W10) welded wire fabric. Place fabric parallel to the proposed finished surface. Support fabric at least ½ inch (13 millimeters) from the existing surface. Provide a minimum 1 inch (25 millimeters) cover over steel items including anchors, reinforcing bars and wire fabric.

(c) Temperature and weather conditions. Conduct cold and hot weather shotcreting operations according to Subsection 552.10. Do not perform shotcrete operations during high winds and heavy rains. Maintain the temperature of the shotcrete mix between 50 and 90 °F (10 and 30 °C). Do not place shotcrete against frozen surfaces. Place shotcrete when the surface and ambient temperature is at least 40 °F (5 °C) and rising.

(d) Shotcrete application. Use the same nozzle operator that created acceptable test panels.

(1) Apply shotcrete within 45 minutes of adding cement to the mixture unless an approved hydration stabilizer is used. If a hydration stabilizer is approved, deliver and place the shotcrete within the approved design discharge time limit up to 3½ hours maximum.

(2) Limit the layer thickness of each shotcrete application to 2 inches (50 millimeters). Thicker applications may be approved if the Contractor can demonstrate that no sloughing or sagging is occurring. If additional thickness is required, broom or scarify the applied surface and allow the layer to harden. Provide a saturated surface dry condition to the surface before applying an additional layer.

(3) Remove laitance, loose material, and rebound. Promptly remove rebound from the work area.

(4) Taper construction joints to a thin edge over a distance of at least 12 inches (300 millimeters). Wet the joint surface before placing additional shotcrete on the joint. Do not use square construction joints.

(5) Finish shotcrete as directed by the CO.

566.08 Curing Shotcrete. Cure the surface according to Subsection 552.15. For intermediate shotcrete surfaces or if a stained or finished final surface is required, cure the shotcrete according to Subsection 552.15(b). If no stained or finished surface is required, apply curing compound to the final exposed shotcrete surface according to Subsection 552.15(c). Maintain shotcrete at a temperature above 40 °F (5 °C) until shotcrete has achieved a minimum compressive strength of 750 pounds per square inch (5.2 megapascals).

566.09 Penetrating Stain. Apply according to the manufacturer's instructions if penetrating stain is used.

566.10 Production Report. Prepare and submit a written report within 24 hours of shotcrete production and application for each shift. Include the following information:

(a) Quantity and location of shotcrete applied including photos of areas where shotcrete was placed;

(b) Observations of success or problems of equipment operation, application, final product condition, and other relevant issues during production and application;

(c) Batch numbers if applicable;

(d) Name of nozzle operator; and

(e) Names and signature of person performing the observation.

566.11 Acceptance. See Table 566-2 for sampling, testing, and acceptance requirements and the quality characteristic category.

Material for shotcrete will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of hydraulic cement.

The shotcrete mixtures air content, density, density, boiling absorption, and permeable void volume will be evaluated under Subsections 106.02 and 106.04. Compressive strength will be evaluated under Subsection 106.05. See Table 566-1 for requirements.

The shotcrete placement system will be evaluated under Subsections 106.02 and 106.04.

Measurement

566.12 Measure the Section 566 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring shotcrete by the cubic yard (cubic meter), measure in place.

Payment

566.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 566 pay items listed in the bid schedule, except the shotcrete contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for shotcrete will be made at a price determined by multiplying the contract price by the compressive strength pay factor.

Table 566-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sample Frequency	Point of Sampling	Split Sample	Reporting Time
Source								
Aggregate quality (703.16)	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsection 703.16	1 per material type	Source of material	Yes	Before producing
Mix Design								
Shotcrete composition	Measured and tested for conformance (106.04)	All	–	Subsection 566.04	1 per mix design	"	Yes	Before producing
Production								
Aggregate (fine & coarse)	Measured and tested for conformance (106.04)	Gradation[(1)]	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes, when requested	Before batching
		Moisture test	–	AASHTO T 255	"	"	"	"

Table 566-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sample Frequency	Point of Sampling	Split Sample	Reporting Time
Shotcrete	Measured and tested for conformance (106.04)	Boiling absorption & permeable void volume [(2)]	–	ASTM C642	1 set per 90 yd^3 (75 m^3), but not less than 1 per job	Production test panels[(4)]	See Note (5)	See Note (6)
		Density	–	AASHTO T 121	1 per load [(3)]	Truck mixer or agitator [(3)]	–	Upon completing tests
		Air content[(2)]	–	AASHTO T 152 or T 196	"	"	–	"
	Statistical (106.05)	Compressive strength[(2)]	II	AASHTO T 24	1 set per 30 yd^3 (25 m^3), but not less than 1 per day	Production test panels[(4)]	See Note (5)	See Note (7)

(1) Gradation requirements are shown in Table 703-11.

(2) Mixture property requirements are shown in Table 566-1.

(3) Sample according to ASTM C1385. See Table 552-9, Note (4) for allowable reductions in sampling and testing frequencies.

(4) Prepare and cure nonreinforced test panels according to ASTM C1140 for mixture properties testing. Construct steel or wood test panel forms to a minimum width and length of 24 inches (600 millimeters) and a minimum depth of 6 inches (150 millimeters) with either square or sloped sides.

(5) Core 3-inch (75-millimeter) diameter samples at least 14 days after the field trial and moisture condition in sealed plastic bags or nonabsorbent containers according to Section 7.3 of AASHTO T 24. As directed by the CO, deliver Government cores to the designated laboratory for testing.

(6) Test at least three samples from each nonreinforced test panel at least 14 days, but no later than 28 days after casting. Samples may consist of cores or pieces of cores as detailed in Subsection 566.06(a)(3).

(7) Test at least three 3-inch (75-millimeter) diameter moisture conditioned cores from each nonreinforced test panel 28 days after casting.

Section 567. — MICROPILES

Description

567.01 This work consists of furnishing and installing micropiles.

Material

567.02 Conform to the following Subsections:

Centralizers and spacers	722.02(e)
Chemical admixtures	711.03
Hydraulic cement	701.01(a)
Neat hydraulic cement grout	725.13(a)(1)
Reinforcing bars	709.01(b)
Steel pipes	715.05(a)
Water	725.01(a)

Construction Requirements

567.03 Qualifications. Provide a professional engineer, on-site supervisors, and installation personnel with experience installing and testing micropiles. Submit the following for approval at least 30 days before starting work:

(a) Names of personnel; and

(b) A résumé for each individual describing their experience on at least five micropile projects of similar complexity over the past 5 years. Include project names, locations, and contact information for project owners.

567.04 Submittals. At least 30 days before starting micropile work, submit the following according to Subsection 104.03:

(a) Start date;

(b) Micropile construction sequence;

(c) Micropile types, sizes, spacings, depths, installation angles, and ultimate strengths for range of material to be encountered;

(d) Tendons, full moment splices permanent casing, and additional hardware with manufacturer’s product data sheets, specifications, catalog cuts, and mill certificates;

(e) Manufacturer recommendations for tendon and hardware handling, storing, assembly, and working temperature ranges. Hollow bar micropiles are unacceptable unless specified or approved by the CO;

(f) Grout type, mix design, mixing equipment, placement procedures, and 7- and 28-day grout compressive strengths test results;

(g) Grouting pressure, volume, and location, if post grouting system is used;

(h) Procedures and material for repairing corrosion protection coatings in the field;

(i) Drilling methods and equipment;

(j) Alternative drilling and grouting methods including grout additives;

(k) Additional material needed to achieve required bond capacities such as grout socks;

(l) Methods to ensure borehole stability during excavation and grout placement;

(m) Micropile testing methods and equipment including type and capacity of reaction load system, drawings, and supporting calculations for structural components of the micropile load test apparatus; and

(n) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

567.05 Installation. Stage micropile installation to avoid interconnection or damage to piles with uncured grout.

Before drilling holes for constructing production micropiles, install pre-production micropiles for verification load tests. Install verification and production micropiles as follows:

(a) Drilling. Provide equipment capable of drilling soil, boulder colluvium and alluvium, and bedrock to anticipated depths. Drill micropile holes to the required diameter and length according to Table 567-1 and the construction schedule and sequence.

If an obstruction prevents the advancement of the pile, abandon the hole and fill the hole with grout. Drill a new hole at a location approved by the CO. Remove drill cuttings and other loose debris from the hole.

(b) Casing, reinforcing bar, and splicing. Place reinforcing bars with centralizers according to Table 567-1. Use centralizers sized to within ½ inch (13 millimeters) of the drill hole diameter.

Construct micropile splices to the required design strength. Align casing joints and reinforcing bar splices to avoid eccentricity or angles at splices. Locate threaded pipe casing joints at least two casing outer diameters from bar splices. When multiple bars are used, stagger the bar splices by at least 12 inches (300 millimeters). If specified or approved, weld according to Subsection 551.11(a).

(c) Grouting. Use a positive displacement grout pump according to Subsection 256.07(b)(1). Use a neat hydraulic cement grout in one continuous operation. Mix admixtures according to the manufacturer’s recommendations. Do not use compressed air to directly pressurize the grout.

Grout the micropile the same day the micropile hole is drilled. Inject grout from the lowest point of the drill hole until clean, pure grout flows from the top of the micropile. Grout may be pumped through tremie tubes, hollow stem augers, or drill rods. Ensure complete continuity of the grout column during all phases of grouting and casing extraction. Control the grout pressures and grout takes to prevent excessive heave in cohesive soils or fractured formations. Grout the entire pile to the design cut-off level.

After grouting is complete, fill the grout tube with grout if it will remain in the hole. Allow grout within the micropiles to attain the minimum design strength before loading.

Observe site conditions in the vicinity of the micropile construction on a daily basis and suspend operations and notify the CO if:

(1) Ground heave, subsidence, or grout leakage is observed;

(2) Micropile structure is adversely affected; or

(3) Adjacent structures are damaged from drilling or grouting.

Table 567-1
Micropile Construction Tolerances

Micropile Attribute	Allowable Variance
Center of micropile	< 3 inches (< 75 millimeters) from indicated plan location or pile spacing
Pile-hole alignment	±2% of design alignment
Top elevation	0 to 1 inch (25 millimeters) above the design vertical elevation
Center of reinforcing steel	< 0.75 inches (< 20 millimeters) from pile center

567.06 Testing and Stressing.

(a) Testing equipment. See Subsection 256.08(a).

(b) Stressing. Place stressing equipment over the micropile so that the jack, bearing plates, load cells, and stressing assembly are axially aligned with the micropile and the micropile is centered within the equipment. Do not apply loads greater 80 percent of the structural capacity of the micropile.

Place the reference pressure gauge in series with the pressure gauge and jack so they need not be unloaded and repositioned during a test. Raise the load from one increment to another. Hold the load for the required time beginning immediately after the load is applied and record the micropile top movement to the nearest 0.001 inch (0.025 millimeters) with respect to an independent fixed reference point. Repump the jack as necessary to maintain a constant load. Monitor the load with a pressure gauge. If the load measured by the pressure gauge and the load measured by the reference pressure gauge differ by more than 10 percent, recalibrate the jack, pressure gauge, and reference pressure gauge.

(1) Verification tests. The CO will designate locations for sacrificial micropiles for verification tests. Test according to Tables 567-2 and 567-4.

Table 567-2
Verification Test Load Schedule

Cycle	Load	Hold Time (Minutes)
1	AL	2.5
	0.15 DL	2.5
	0.30 DL	2.5
	0.45 DL	2.5
2	AL	1
	0.15 DL	1
	0.45 DL	1
	0.60 DL	2.5
	0.75 DL	2.5
	0.90 DL	2.5
	1.00 DL	2.5
	AL	1
4	0.15 DL	1
	1.00 DL	1
	1.15 DL	2.5
	1.30 DL (Load-hold test)	60*
	1.45 DL	2.5
	AL	1
5	0.15 DL	1
	1.45 DL	1
	1.60 DL	1
	1.75 DL	2.5
	1.90 DL	2.5
	2.00 DL (Maximum test load)	10
	1.50 DL	5
	1.00 DL	5
	0.50 DL	5
	AL	5

AL = Alignment load (no greater than 10 percent of DL (0.10 DL) applied to the pile before setting the movement recording devices. Zero dial gauges after the first setting of AL).

DL = Unfactored design load.

* Hold the load to within 2 percent and measure and record pile top movement at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes.

A verification test is acceptable based on one of the following results:

(a) Total vertical movement does not exceed 0.375 inches (9.5 millimeters) under DL. If an AL is used, then the allowable movement will be reduced by multiplying by a factor of (DL-AL)/DL;

(b) Deflection rate is linear or decreasing and does not exceed 0.040 inch (1 millimeter) per log cycle time from 1 to 10 minutes or 0.080 inch (2 millimeters) per log cycle time from 6 to 60 minutes under 1.30 times the DL; or

(c) Slope of the load versus deflection (at end of increment) curve does not exceed 0.025 inch per kip (0.065 millimeters per Newton) at each test load increment.

If the micropile verification is unacceptable, test another to establish the cause and make design or construction modifications. These modifications may include installing replacement test micropiles, modifying the installation methods, increasing the bond length, regrouting with pre-placed re-grout tubes, or changing the micropile type. Submit modifications requiring changes to the structure and retest the new system as directed by the CO.

Submit micropile geometry, construction, testing details, and verification test results for approval before installing production micropiles.

Remove verification test micropiles to an elevation below existing ground level.

If construction methods or foundation material change, perform additional verification tests.

(2) Proof tests. The CO will designate production micropiles for proof testing. Test according to Tables 567-3 and 567-4.

A proof test is acceptable based on one of the following results:

(a) Total vertical movement does not exceed 0.5 inches (13 millimeters) under the unfactored design load (DL). If an alignment load (AL) is used, then the allowable movement will be reduced by multiplying by a factor of (DL-AL)/DL;

(b) Deflection rate is linear or decreasing and does not exceed 0.040 inch (1 millimeter) per log cycle time from 1 to 10 minutes or 0.080 inch (2 millimeters) per log cycle time from 6 to 60 minutes under 1.30 times the unfactored design load (1.30 DL); or

(c) Slope of the load versus deflection (at end of increment) curve does not exceed 0.025 inch per kip (0.065 millimeters per Newton) under the maximum test load (1.60 DL.)

If a proof-tested micropile is unacceptable, proof test another micropile in the immediate vicinity. Establish the cause and make design or construction modifications for future piles. Submit modification requiring changes to the structure for approval.

Table 567-3
Proof Test Load Schedule

Load	Minimum Hold Time (Minutes)
AL	2.5
0.15 DL	2.5
0.30 DL	2.5
0.45 DL	2.5
0.60 DL	2.5
0.75 DL	2.5
0.90 DL	2.5
1.00 DL	2.5
1.15 DL	2.5
1.30 DL (Load-hold test)	10*
1.45 DL	2.5
1.60 DL (Maximum test load)	2.5
1.30 DL	4
1.00 DL	4
0.75 DL	4
0.50 DL	4
0.25 DL	4
AL	4

AL = See alignment load note in Table 567-2.

DL = Unfactored design load.

* Hold the load to within 2 percent and measure and record pile top movement at 1, 2, 3, 4, 5, 6, and 10 minutes. If the movement measured between 1 and 10 minutes exceeds 0.04 inches (1 millimeter), continue holding the load and measure and record pile movement at 20, 30, 50, and 60 minutes.

567.07 Test Results and Reporting. Provide preliminary results for each micropile tested to the CO before testing personnel leave the site. Submit detailed verification and proof test load and deflection data in a tabular format. Submit a graph that plots total micropile top movement versus load, the A-line, and the B-line. The A-line is defined as 0.8 multiplied by the theoretical free test length elastic elongation. The B-line is defined as the theoretical free test length elastic elongation plus 0.50 multiplied by the theoretical bond length elastic elongation. Allow 5 days for the CO to conduct a review of the data and approve micropile installation.

567.08 Acceptance. See Table 567-4 for sampling, testing, and acceptance requirements.

Material for micropiles will be evaluated under Subsection 106.03. Submit a production certification with each shipment of structural steel and casing.

Construction of micropiles will be evaluated under Subsections 106.02 and 106.04.

Reinforcing bars will be evaluated under Section 554.

Measurement

567.09. Measure the Section 567 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When production micropiles are measured by the linear foot (meter); measure from the plan top elevation to the approved tip elevation.

Do not measure failed proof or verification tests or additional tests to verify alternative micropile installation methods proposed by the Contractor.

Payment

567.10. The accepted quantities will be paid at the contract price per unit of measurement for the Section 567 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 567-4
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Neat hydraulic cement grout (725.13)	Measured and tested for conformance (106.04)	Compressive strength	–	ASTM C942	1 per mix design	Source of material	Yes	Before producing	–
Production									
Neat hydraulic cement grout (725.13)	Measured and tested for conformance (106.04)	Density	–	AASHTO T 133	1 per 5 piles	Mixer	No	24 hours	–
		Flow	–	ASTM C939	"	Point of discharge	"	Upon completion of test	–
		Compressive strength	–	ASTM C942	1 set of 3 samples(1)	Grout plant	"	"	–
Verification test micropile	"	Performance	–	Subsection 567.06(b)(1)	All	Installation	No	5 days	–
Proof test micropile	"	Performance	–	Subsection 567.06(b)(2)	1 in 20	"	"	"	–

(1) From each grout plant per day of operation or per five micropiles, whichever occurs more frequently.

Section 568. — HIGH PERFORMANCE CONCRETE

Description

568.01 This work consists of furnishing, placing, finishing, and curing high performance concrete (HPC) in bridge decks, approach slabs, and other structural elements.

In addition to the Section 552 structural concrete properties, HPC conforms to performance characteristics for the following:

(a) Maximum chloride permeability. Total charge in coulombs passed over a specified period of time according to AASHTO T 277, except as modified in Table 568-2.

(b) Drying shrinkage. Drying shrinkage in microstrains according to ASTM C157, except as modified in Table 568-2.

Material

568.02 Conform to the following Subsections:

Air-entraining admixtures	711.02
Chemical admixtures	711.03
Coarse aggregate for concrete	703.02
Color coating	725.15
Concrete coloring agents	711.05
Curing material	711.01
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Pozzolans	725.04
Reinforcing fibers	725.17
Water	725.01(a)

Construction Requirements

568.03 Qualifications. Provide an on-site supervisor with experience completing of at least two HPC projects of similar complexity within the last 3 years.

568.04 Composition (Concrete Mix Design). Design and produce concrete mixtures that conform to the following:

(a) Tables 552-3 and 568-1; and

(b) Chapter 5 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary* for determining required average compressive strength (f'_{cr}).

Submit HPC mix designs on FHWA Form 1608, *552 Structural Concrete Mix Design Submittal*.

Verify mix designs with trial mixes prepared according to ACI 318 from proposed sources or with previous concrete production data for the mixture design submitted from proposed sources. Verify the performance characteristics and plastic properties in Table 568-1. Submit written concrete mix designs for approval at least 36 days before production. Include the items listed in Subsection 552.03 in each concrete mix design submittal.

Begin production only after the mix design is approved.

Furnish a new mix design for approval if there is a change in a source of material source or when the fineness modulus of the fine aggregate changes by more than 0.20.

568.05 Strength-Maturity Relationship. For the approved concrete mix design and anticipated weather, develop a strength-maturity relationship according to AASHTO T 325. Submit the relationship for approval at least 14 days before production. Develop a new relationship if changes in the mix constituents, hydration stabilizer dosage, or weather affect the relationship.

Provide a concrete maturity meter for the test section and production that:

(a) Conforms to AASHTO T 325;

(b) Is rugged, waterproof, and able to withstand the construction environment;

(c) Operates without an external power source for at least 14 days;

(d) Collects and stores temperature and maturity data for at least 14 days; and

(e) Determines equivalent maturity hours according to the Arrhenius function.

568.06 Test Section. For bridge decks, approach slabs, and other flatwork, construct a 9-foot by 9-foot by 8-inch (3-meter by 3-meter by 200-millimeter) test section. For other structural elements, construct a 3- by 3- by 3-foot (1- by 1- by 1-meter) test section. Use the approved concrete mix design and the same methods of handling, placing, monitoring, finishing, curing, and cleaning as intended for production placement. Sample and test for Table 568-1 conformance.

Use the strength-maturity relationship developed for the approved mix design to determine in-place concrete compressive strength. Verify that the test section concrete has a similar time temperature relationship.

Begin production only after the test section is evaluated and accepted.

Table 568-1
Performance Characteristics and Plastic Properties of HPC

Property	Specification
Chloride permeability, AASHTO T 277, except as modified in Table 568-2	1,500 coulombs maximum at 28 days
Drying shrinkage, ASTM C157, except as modified in Table 568-2	500 microstrains maximum
Compressive strength, AASHTO T 22	5,000 pounds per square inch (34.5 MPa) minimum at 28 days
Water/cementitious material ratio	0.45 maximum
Aggregate size	¾ inches (19 millimeters) nominal maximum
Total cementitious content (1)	517 to 846 pounds per cubic yard (307 to 502 kilograms per cubic meter)
Slump (2), AASHTO T 119	2 to 8 inches (50 to 200 millimeters)
Air content (3), AASHTO T 152 or AASHTO T 196	See Subsection 552.03
Sulfate resistance	AASHTO M 240, Type IP(MS) or Type IS(< 70)(MS) (use Type II cement (4)(5) per AASHTO M 85)
Water-soluble chloride ion content, ASTM C1218 (6)	0.15 percent by mass of cement maximum for reinforced concrete 0.06 percent by mass of cement maximum for prestressed concrete

(1) The total cementitious content includes portland cement and all pozzolans added to the concrete mixture (such as ground granulated blast furnace slag, fly ash, and silica fume).

(2) Slump can be adjusted using a high range water reducer (superplasticizer) as long as the maximum water/cementitious material ratio is not exceeded. Include the water contained in the aggregates above the amount of absorbed water in the calculation of the water/cementitious material ratio.

(3) If the plastic air content is low when the concrete arrives on-site, additional air-entraining agent may be added to the concrete and mixed provided that 300 revolutions of the mixer has not been exceeded.

(4) For seawater exposure, other portland cement types are permitted if the tricalcium aluminate (C_3A) content is 10 percent or less and the water/cementitious material ratio is 0.40 or less.

(5) Other cement types are permitted if the C_3A content is less than 8 percent.

(6) Determine the water-soluble chloride ion content contributed from the ingredients including water, aggregates, cementitious material, and admixtures between ages 28 and 42 days.

568.07 Handling and Storing Material. See Subsection 552.04.

568.08 Measuring Material. See Subsection 552.05.

568.09 Batching Plant, Mixers, and Agitators. See Subsection 552.06.

568.10 Mixing. See Subsection 552.07.

When required, add reinforcing fibers to the concrete mixture following manufacturer's recommendations. Mix until uniformly distributed in the concrete mixture. Gradually add fibers to the concrete mixture.

568.11 Delivery. See Subsection 552.08, except do not use nonagitating equipment.

If reinforcing fibers reduce the workability, do not add additional water to concrete mixture. If approved by the CO, add a water reducing admixture conforming to AASHTO M 194 or a high range water reducing admixture.

568.12 Quality Control of Mix. See Subsection 552.09.

Deliver and sample concrete according to Subsection 552.09(b), except as modified in Table 568-2.

568.13 Temperature and Weather Conditions. Before placement, maintain the temperature of the concrete between 50 and 80 °F (10 and 27 °C).

Install maturity meter probes and monitor concrete temperatures according to AASHTO T 325. Monitor the temperature differential from the center of the concrete mass to its surface. Provide internal cooling, external heating, or insulation to insure the temperature differential does not exceed 35 °F (20 °C) during placing, curing, cooling, form stripping, and after curing ends.

During curing, maintain the temperature of the concrete mass interior below 140 °F (60 °C) and temperature of the outer most surfaces above 45 °F (7 °C).

(a) Cold weather. See Subsection 552.10(a), except as follows:

(1) Place concrete for flatwork only when the ambient air temperature is 45 °F (7 °C) and rising. Place concrete for other structural elements only when the ambient air temperature is 35 °F (2 °C) and rising;

(2) Protect concrete until the concrete maturity data indicates that minimum compressive strength is achieved; and

(3) At the end of the protection period, start the cooling process when the average wind speed is less than 10 miles (16 kilometers) per hour as measured 3 feet (1 meter) from the concrete surface.

(b) Hot weather. See Subsection 552.10(b), except as follows:

(1) Place concrete when the ambient air temperature is less than 85 °F (30 °C.);

(2) Do not remove curing material until the concrete maturity data indicates that minimum compressive strength is achieved and the moist curing period is complete; and

(3) Do not remove curing material until the calculated evaporation rate is less than 0.15 pounds per square foot (0.74 kilograms per square meter) per hour as determined by Figure 552-1.

(c) Evaporation. Do not place concrete if the predicted evaporation rate, determined without fogging and other protective measures, is greater than 0.15 pounds per square foot (0.74 kilograms per square meter) per hour as determined by Figure 552-1. For wind speed, use an anemometer with full scale accuracy to within 4 percent and for relative humidity, use a psychrometer or hygrometer with full scale accuracy to within 2 percent. Measure wind speed and relative humidity 24 inches (600 millimeters) above the concrete surface.

Before placing, install and demonstrate fogging equipment for approval and identify personnel to operate the equipment.

While placing, finishing, and curing surfaces; take care to prevent crusting and plastic shrinkage cracking. Do not allow the surface of the freshly placed concrete to dry. Use fogging, windbreaks and other protective measures as necessary to limit the expected evaporation rate to less than 0.1 pound per square foot (0.5 kilogram per square meter) per hour as determined by Figure 552-1.

Use pressure sprayers or atomizers to maintain a moist surface. Do not apply moisture under pressure directly to the concrete surface. Do not allow water to accumulate to cause a flow or wash on the concrete surface. Continue fogging the concrete surface until finishing operations are complete and the surface is covered. Do not wait until final set to cover the concrete surface.

(d) Rain. Protect the concrete from rain during and after placement.

568.14 Handling and Placing Concrete. See Subsection 552.11.

568.15 Construction Joints. See Subsection 552.12.

568.16 Expansion and Contraction Joints. See Subsection 552.13.

568.17 Finishing Plastic Concrete. See Subsection 552.14.

568.18 Concrete Curing. Begin curing within 4 hours after the concrete achieves final set.

(a) Flatwork curing. Use the water method according to Subsection 552.15(b). Apply soaker hoses or other approved methods to keep the coverings saturated. Keep the concrete saturated and covered for the entire curing period.

(b) Structural elements. Use a combination of the forms in-place method according to Subsection 552.15(a) and the water method according to Subsection 552.15(b). If forms are stripped or loosened before the end of the curing period, complete the remainder of the curing using the water method.

During hot and cold weather, cure until the in-place concrete compressive strength reaches the minimum shown in Table 568-1 at measured locations according to AASHTO T 325. At other times, cure until the in-place compressive strength reaches 80 percent of the minimum shown in Table 568-1. Cure flatwork at least 14 days and structural elements at least 10 days.

If directed by the CO after curing, clean staining or efflorescence to provide a uniform color to the concrete surface.

568.19 Texturing Driving Surfaces. After curing, produce a skid-resistant surface by saw cutting grooves according to Subsection 552.14(c)(1).

568.20 Acceptance. See Table 568-2 for sampling, testing, and acceptance requirements and the quality characteristic category.

Material for HPC will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of cementitious material.

The concrete mixture's slump, air content, density, and temperature will be evaluated under Subsections 106.02 and 106.04.

Concrete compressive strength will be evaluated under Subsection 106.05. The lower specification limit is the minimum required compressive strength at 28 days (f_c') shown in Table 568-1. Remove and replace concrete represented by cylinders having a compressive strength less than 90 percent of the minimum 28-day compressive strength (f_c').

Maximum chloride permeability will be evaluated under Subsection 106.05. The upper specification limit is the maximum specified chloride permeability value at 28 days shown in Table 568-1.

Drying shrinkage will be evaluated under Subsection 106.04. The upper specification limit is the maximum shown in Table 568-1. If the concrete mixture contains 1.5 gallons per cubic yard (7.5 liters per cubic meter) of an approved shrinkage reducing admixture, drying shrinkage testing is not required and drying shrinkage will be evaluated under Subsection 106.03.

Construction (including batching, placing, finishing, and curing concrete) of HPC structures will be evaluated under Subsections 106.02 and 106.04.

Falsework and forms will be evaluated under Section 562.

Measurement

568.21 Measure the Section 568 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring HPC by the cubic yard (cubic meter), measure in the structure.

Payment

568.22 The accepted quantities will be paid at the contract price per unit of measurement for the Section 568 pay items listed in the bid schedule, except the HPC contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for HPC will be made at a price determined by multiplying the contract price by the lower of the two pay factors determined for compressive strength or chloride permeability.

Table 568-2
Sampling and Testing Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (703.01 & 703.02)	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsections 703.01 & 703.02 including ASR requirements	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Concrete composition	Measured and tested for conformance (106.04)	All	–	Subsection 568.04	1 per mix design	"	Yes	"	–
Production Start-up (test section)									
HPC	Measured and tested for conformance (106.04) [(1)]	Maximum[(2)] chloride permeability	–	AASHTO T 277	1 set per test placement	Discharge stream at point of placement	Yes	Upon completing tests	–
		Compressive strength[(3)]	–	AASHTO T 23 & 22	"	"	"	"	–
		Drying[(4)(5)] shrinkage	–	ASTM C157	"	"	"	"	–
Production									
Produced aggregate (fine & coarse)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–

Table 568-2 (continued)
Sampling and Testing Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
HPC	Measured and tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load	Point of discharge	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump[6]	–	AASHTO T 119	"	"	No	"	–
		Temperature	–	ASTM C1064	"	"	No	"	–
		Drying[4][5] shrinkage	–	ASTM C157	1 set per 75yd^3 (57 m^3)	"	"	"	–
HPC	Statistical (106.05)	Maximum chloride permeability[2]	II	AASHTO T 277	1 set per 30 yd^3 (23 m^3), but not less than 1 per day	Discharge stream at point of placement	Yes	Upon completing tests	–
		Compressive strength[7]	II	AASHTO T 23 & T 22	"	"	"	"	–

Table 568-2 (continued)
Sampling and Testing Requirements

(1) Sample according to AASHTO R 60, except composite samples are not required.

(2) Cast at least three 4- by 8-inch (100- by 200-millimeter) maximum chloride permeability cylinders per set and carefully transport the cylinders to the job site curing facility. Cure the cylinders for 7 days according to AASHTO M 201. Then cure at 100 °F ± 10 °F (38 °C ± 5 °C) in saturated lime water until AASHTO T 277 sample conditioning begins. Have the testing done at 28 days in an independent laboratory that is qualified to perform the testing and is approved by the CO. The set test result is the average of the measurements on three cylinders cast from the same load. If pigment is used in the concrete mixture, sample concrete at the batch plant before and after adding pigment. Test at least three specimens with and without pigment. Determine the average difference between the pigmented and nonpigmented test results. Adjust production test result by the average difference. Report both initial and adjusted test results.

(3) Cast at least eighteen 4- by 8-inch (100- by 200-millimeter) compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Have the testing done at 1, 3, 7, 14, and 28 days in an independent laboratory that is qualified to perform the testing and is approved by the CO. A single compressive strength test result is the average result from three cylinders cast from the same load.

(4) Drying shrinkage testing is not required if the concrete mixture contains 1.5 gallons per cubic yard (7.5 liters per cubic meter) of an approved shrinkage reducing admixture.

(5) If testing is required, use 3- by 3- by 11-inch (75- by 75- by 275-millimeter) prisms for drying shrinkage specimens. Cast at least three drying shrinkage prisms per set and carefully transport the prisms to the job site curing facility. Moist the prisms for the duration of the specified moist curing period for HPC elements. Have the testing done in an independent laboratory that is qualified to perform the testing and is approved by the CO. The zero measurement for percent drying shrinkage is the initial measurement taken at demolding of the specimens at 23½±½ hours after introduction of mixing water to the concrete mixture. Measure percent drying shrinkage at the end of specified moist curing period for the structural elements, 1, 4, 7, 14, 28, and 56 days after the end of the specified field moist curing period. Drying shrinkage 28 days after the termination of moist curing (28 days drying) cannot exceed 60 percent of the maximum specified value. The set drying shrinkage test result is the average result from three prisms cast from the same load.

(6) If reinforcing fibers are used at an addition rate greater than 0.3 percent by volume, measure slump at the batch plant before the addition of fibers.

(7) Cast at least six 4- by 8-inch (100- by 200-millimeter) compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders at 28 days. Use the remainder of cylinders as designated by the CO.

Section 569. — CONCRETE OVERLAYS FOR BRIDGE DECKS

Description

569.01 This work consists of furnishing, placing, finishing, and curing concrete for bridge deck overlays including the preparation of existing deck surfaces.

Concrete overlay class is designated high performance concrete overlay (HPC(O)) or latex-modified concrete (LMC) according to Table 569-1.

Material

569.02 Conform to the following Subsections:

Air-entraining admixtures	711.02
Chemical admixtures	711.03
Coarse aggregate for concrete	703.02
Concrete coloring agents	711.05
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Latex emulsion admixture	711.04
Pozzolans	725.04
Reinforcing fibers	725.17(b)
Water	725.01(a)

Construction Requirements

569.03 Qualifications. Provide an on-site supervisor with experience completing of at least two overlay projects with the specific overlay class within the last 3 years.

569.04 Composition (Concrete Mix Design). Design and produce concrete overlay mixtures that conform to following:

(a) Table 569-1 for the class specified; and

(b) Chapter 5 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary* for determining required average compressive strength (f'_{cr}).

Table 569-1
Composition of Concrete

Concrete Overlay Class	Property					Performance Characteristics			
	Total Cementitious Material Content[1] pounds/yard^3 (kg/m^3)	Maximum Water to Cementitious Material Ratio[3]	Slump inches (mm)	Air Content (%)	Course Aggregate Size Number AASHTO M43 [4]	Maximum Chloride Permeability AASHTO T 277 coulombs	Maximum Dry Shrinkage[5] ASTM C157 microstrains	Average Bond Strength at 14 Days ASTM C1583 pounds/inch^2 (megapascals)	Minimum Compressive Strength AASHTO T 22 pounds/inch^2 (megapascals)
HPC(O)	564 to 846 (335 to 502)	0.45	2 to 8 (50 to 200)	Table 552-2	#7, #78, #8	1,500	500	150 (1.03)	4,500 (31)
LMC[2]	564 to 846 (335 to 502)	0.45	2 to 8 (50 to 200)	3.0 to 10.0	#7, #78, #8	1,500	–	150 (1.03)	4,000 (28)

(1) The total cementitious material content includes portland cement and all pozzolans added to the concrete mixture (such as ground granulated blast furnace slag, fly ash, and silica fume). Meet the requirements of Table 552-3.

(2) Add 3.5 gallons (15 liters) of latex emulsion per 94 pounds (43 kilograms) of cement.

(3) Include the water contained in the aggregates above the amount of absorbed water in the calculation of the water-to-cementitious material ratio.

(4) Meet the processing requirements of AASHTO M 43, *Table 1 – Standard Sizes of Processed Aggregate*. Do not use gravel or alkali-silica reactive aggregates.

(5) Dry shrinkage testing is not required if the concrete mixture contains 1.5 gallons per cubic yard (7.5 liters per cubic meter) of an approved shrinkage reducing admixture.

Submit concrete overlay mix designs on FHWA Form 1608, *552 Structural Concrete Mix Design Submittal*.

Verify the mix designs with trial mixes prepared according to ACI 318 from proposed sources or with previous concrete production data for the mixture submitted from proposed sources. Verify the performance characteristics in Table 569-1. Submit written concrete mix designs for approval at least 36 days before production. Include the items listed in Subsection 552.03(a) through (y) in each mix design submittal.

Furnish a new mix design for approval if a source of material changes or if the fine aggregate fineness modulus changes by more than 0.20.

569.05 Strength-Maturity Relationship. See Subsection 568.05.

569.06 Surface Preparation. Remove asphalt, asphalt membranes, and concrete overlays without damaging the concrete bridge deck. Use micro milling machine to remove existing overlays. Sound the bridge deck according to ASTM D4580 to identify unsound concrete in deck. Do not perform surface preparation within 6 feet (1.8 meters) of a new overlay until 48 hours after its placement. Submit a repair plan for approval by the CO that includes the following:

(a) Concrete repairs. Determine the depth of concrete cover over the existing reinforcement using a covermeter or ground penetrating radar. Remove unsound concrete according to Subsections 203.04(b) and 203.04 (c). Prepare and repair concrete according to Section 502.

Remove at least 1 inch (25 millimeters) of concrete around exposed or unbounded reinforcement. Remove and replace deteriorated reinforcement.

Within 24 hours before placing repair concrete, clean exposed concrete surfaces, reinforcement, and structural steel of rust and foreign material by abrasive shot blasting and pressurized water flushing.

In repair areas larger than 2 square feet (0.19 square meters) with exposed reinforcement, install pre-packaged zinc sacrificial anodes on the reinforcement according to manufacturer's recommendations.

(1) In areas larger than 2 square feet (0.19 square meters) and smaller than 4 square feet (0.37 square meters), install a pair of anodes on the reinforcement. Install the anodes at opposite sides of the repair and within 6 inches (150 millimeters) of the edge of the repair; and

(2) In areas 4 square feet (0.37 square meters) and larger, install an additional pair of anodes for each incremental 4-square foot (0.37-square meter) increase in the repair area.

Use a concrete mixture conforming to Table 552-1 Class C(AE) concrete to fill the repair area. In repair areas not containing anodes, an approved high strength concrete patching compound placed according to the manufacturer's recommendations may be used. Fill repair areas level with the surface of the surrounding concrete deck.

Cure repair areas according to Subsection 552.15(b) until the concrete obtains a compressive strength of 3000 pounds per square inch (21 megapascals).

(b) Surface profiling. Provide a minimum profile of $^{1}/_{16}$ inch (1.6 millimeters) and a maximum of ¼ inch (6 millimeters) on the substrate concrete to bond with the concrete. Use hydrodemolition according to Section 560 or a micro milling machine.

After surface profiling approval and within 36 hours of expected overlay placement, shotblast and pressure wash the substrate concrete. Use a potable water source with a minimum water pressure of 4000 pounds per square inch (55 megapascals). Remove concrete laitances, oils, fuels, and other foreign and loose material detrimental to achieving a sufficient bond. Capture debris from shotblasting and pressure washing and properly dispose of it off site. Cover the prepared surface with polyethylene sheeting to prevent contamination.

(c) Saturation. Thoroughly water-soak the clean concrete surface for at least 24 hours before placing the overlay concrete. Do not use burlap. Remove puddles of standing water using a vacuum or other approved equipment. Do not use a blower or compressed air to remove water.

569.07 Test Section. Prepare the substrate concrete surface using the same methods intended for the overlay placement. Construct a 9- by 9-foot (3- by 3-meter) test section on the substrate concrete at the same thickness as the overlay. Use the approved concrete mix design and the same methods of handling, placing, finishing, and curing intended for actual placement. Sample and test for Table 569-1 conformance.

Demonstrate the maturity meter operation. Use the strength-maturity relationship developed for the approved mix design to determine in-place compressive strength. Verify that the test section concrete has a similar time temperature relationship. Demonstrate methods for conforming to temperature requirements in Subsection 569.14.

Demonstrate methods for cleaning staining or efflorescence to provide uniform color on the concrete surface.

Begin production only after the test panel is evaluated and accepted.

569.08 Handling and Storing Material. See Subsection 552.04.

Protect latex emulsion from freezing and prolonged exposure to temperatures in excess of 85 °F (29 °C). Store containers of latex admixture at the bridge site for a period not to exceed 10 days.

569.09 Measuring Material. See Subsection 552.05.

569.10 Batching Plant, Mixers, and Agitators. See Subsection 552.06 and the following:

(a) Class HPC(O). Furnish ready-mixed concrete produced and delivered according to AASHTO M 157.

(b) Class LMC. Furnish proportioning and mixing equipment with an integral mobile unit with continuous mixing capability. Furnish a mixer with the following capabilities:

(1) Capable of producing at least 6.0 cubic yards (4.6 cubic meter) of concrete without recharging;

(2) Equipped with a cement metering device and recording meter accurate within a tolerance of minus 1 to plus 3 percent and with a ticket printout device to record the cement quantity added to the mix;

(3) Equipped with a latex tank with a standpipe marked in gallons (liters) and a latex metering device accurate within a tolerance of minus 1 to plus 2 percent;

(4) Equipped with a water flow control and flow indicator accurate within a tolerance of 2 percent in the range of expected use that is readily adjustable to provide for minor variations in aggregate moisture content;

(5) Equipped with controls to regulate the quantity of other components required to produce the specified mix; and

(6) Capable of discharging the mixture through a conventional chute directly in front of the finishing machine.

Calibrate LMC equipment with material for the approved mix design within 6 months of the placement date. Keep the equipment maintained, calibrated, clean, and free of partially dried or hardened material.

569.11 Mixing. See Subsection 552.07 and the following:

Add reinforcing fibers to the concrete mixture following the manufacturer's recommendations. Add fibers to the concrete mixture gradually to ensure the fibers are uniformly distributed throughout the concrete mixture.

569.12 Delivery. See Subsection 552.08, except do not use nonagitating equipment.

(a) Class HPC(O). If reinforcing fibers reduce workability, do not add additional water to the concrete mixture. Adjust workability using admixtures from the approved mix design.

If the air content is low when the concrete arrives on-site, add air-entraining agent and mix.

(b) Class LMC. Deliver concrete through the conventional chute of an integral mobile volumetric mixer directly in front of the finishing machine.

569.13 Quality Control of Mix. See Subsection 552.09, except as modified in Table 569-2.

569.14 Temperature and Weather Conditions. Before placement, maintain the temperature of the overlay concrete mixture between 45 and 80 ºF (7 and 27 ºC).

Install maturity meter probes and monitor concrete temperatures according to AASHTO T 325. Monitor the temperature differential from the center of the concrete mass to the surface. Provide internal cooling, external heating, or insulation to ensure the temperature differential does not exceed 35 °F (20 ºC) during placing, curing, and immediately after curing ends.

Using the strength-maturity relationship developed for the approved concrete mixture determine in-place concrete compressive strength of the overlay. Measure concrete temperature and calculate in-place maturity.

(a) Cold weather. See Subsection 568.13(a).

(b) Hot weather. See Subsection 568.13(b).

(c) Evaporation. See Subsection 568.13(c).

(d) Rain. See Subsection 552.10(d).

569.15 Handling and Placing Concrete. See Subsection 552.11.

(a) General. See Subsection 552.11(a).

(b) Placing methods. See Subsection 552.11(c) and the following:

(1) Class HPC(O). Do not broom mortar from the concrete from the front edge of the placement.

(2) Class LMC. Immediately ahead of placing overlay mixture, broom a thin coat of the concrete overlay mixture and scrub it into the surface as a grout-bond coat at the front edge of the placement. Work evenly over the surface in front of the front edge of the placement.

(c) Consolidation. See Subsection 552.11(d).

Use a self-propelled finishing machine capable of forward and reverse movement under positive control. Ensure the length of the screed is sufficient to extend at least 6 inches (150 millimeters) beyond the edge of both ends of the section being placed. Provide finishing machine capable of consolidating the concrete by vibration and of raising screeds to clear the concrete for traveling in reverse. Provide either a rotating roller-type or an oscillating screed-type finishing machine.

Use rotating roller-type machines with one or more rollers, augers, and 1,500 to 2,500 vibrations per minute (25 to 42 hertz) vibratory pans.

Use oscillating screed-type machines with vibrators on the screeds whose frequency of vibration can be varied between 3,000 and 15,000 vibrations per minute (50 to 250 hertz). Use metal screeds with a bottom face of not less than 4 inches (100 millimeters) wide.

Use handheld vibrators at the concrete edges and adjacent to expansion joints.

569.16 Construction Joints. See Subsection 552.12 and the following:

Form the vertical edge at construction joints by bulkhead or saw cut. Make construction joints straight and vertical**.**

569.17 Expansion and Contraction Joints. See Subsection 552.13.

569.18 Finishing Plastic Concrete. See Subsection 552.14 and the following:

(a) Use a self-propelled rotating cylinder machine, either single or double roller that is capable of forward or reverse movement under positive control. Equip the machine with an oscillating screed and other devices required to continuously spread, consolidate, and finish the plastic concrete. Ensure the screed extends the full width of the deck;

(b) Produce a longitudinal trowelled finish along the gutter line for a 12-inch (300-millimeter) width from the curb face; and

(c) Proceed at a constant rate so final finishing is complete before a plastic film forms on the concrete surface. Install a construction dam or bulkhead in case of major delay. During minor delays of 1 hour or less, protect the end of the placement from drying with layers of wet burlap.

569.19 Concrete Curing. Prevent plastic shrinkage cracking and crusting of the surface. Use the water method of curing according to Subsection 552.15(b). Use washed burlap and apply soaker hoses or other approved methods to keep the coverings saturated at all times.

Install maturity meter probes and monitor concreter temperatures according to AASHTO T 325. Maintain the concrete temperature of the outer most surfaces above 45 °F (7 °C). Monitor the temperature differential from the center of the concrete mass to its surface. Using the strength-maturity relationship developed for the approved concrete mixture, determine the in-place concrete compressive strength of the concrete.

(a) Class HPC(O). Wet cure the concrete for at least 14 days. Provide internal cooling, external heating, or insulation to ensure the temperature differential does not exceed 35 °F (20 °C). Cure until the in-place concrete compressive strength of the overlay concrete reaches at least 80 percent of the minimum compressive strength shown in Table 569-1.

(b) Class LMC. Wet cure the concrete for at least 48 hours and until the maturity meter reading exceeds 48 maturity hours. Then air cure the concrete for an additional 48 hours and until the maturity meter reading exceeds 96 maturity hours.

569.20 Texturing. After curing, visually inspect the overlay for cracking or other damage and inspect for delamination. Perform bond test. Remove and replace delaminated or unbounded portions of the overlay or portions damaged by rain for freezing. Clean staining or efflorescence to provide a uniform color to the concrete overlay surface.

After the Table 569-1 bond strength is obtained, groove surface according to Subsection 552.14(c)(1).

Continuously remove slurry and other residue from the overlay by vacuum pickup or other approved methods. Properly dispose of slurry and other residue off site.

569.21 Acceptance. See Table 569-2 for sampling, testing, and acceptance requirements and the quality characteristic category.

Material for concrete repair will be evaluated under Subsection 106.03.

Material for overlay concrete will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of cementitious material.

The overlay concrete mixture’s slump, air content, density, and temperature will be evaluated under Subsections 106.02 and 106.04.

Overlay concrete compressive strength will be evaluated under Subsection 106.05. The lower specification limit is the minimum required compressive strength at 28 days (fc’) shown in Table 569-1. Remove and replace concrete represented by cylinders having a compressive strength less than 90 percent of fc’.

Maximum chloride permeability will be evaluated under Subsection 106.05. The upper specification limit is the maximum specified chloride permeability value shown in Table 569-1. A single chloride permeability test result is the average result from 2 samples cast from the same load and tested.

Concrete drying shrinkage for Class HPC(O) will be evaluated under Subsection 106.04. The upper specification limit is the maximum shown in Table 569-1. If the concrete mixture contains 1.5 gallons per cubic yard (7.5 liters per cubic meter) of an approved shrinkage reducing admixture, drying shrinkage testing is not required and drying shrinkage will be evaluated under Subsection 106.03.

Bond strength of the overlay will be evaluated under Subsection 106.05. The lower specification limit is the minimum required bond strength at 14 days shown in Table 569-1.

Construction of concrete overlays for bridge decks will be evaluated under Subsections 106.02 and 106.04.

Measurement

569.22 Measure the Section 569 pay items listed in the bid schedule according to Subsection 109.02.

Payment

569.23 The accepted quantities will be paid at the contract price per unit of measurement for the Section 569 pay items listed in the bid schedule, except the overlay concrete contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for overlay concrete will be made at a price determined by multiplying the contract price by the lower of the three pay factors determined for compressive strength, chloride permeability, or bond strength.

Table 569-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (703.01 & 703.02)	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsections 703.01 and 703.02	1 per material type	Source of material	Yes, when requested	Minimum 36 days before production	Reports must be dated within 1 year of intended use
Mix Design									
Concrete composition	Measured and tested for conformance (106.04 & 105)	All	–	Subsection 569.04	1 per mix design	Source of material	Yes, when requested	Minimum 36 days before production	–
Production Start-up (test panel)									
HPC(O)	Measured and tested for conformance (106.04)	Maximum chloride permeability[1]	–	AASHTO T 277	1 set per test placement	Discharge stream at point of placement[1]	Yes, when requested	Upon completing tests	–
		Compressive strength[2]	–	AASHTO T 23 & 22	"	"	"	"	–
		Drying shrinkage[4] [5]	–	ASTM C157	"	"	"	"	–
		Tensile bond strength	–	ASTM C1583	5 cores per test placement	In-place after curing is complete	"	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
LMC	Measured and tested for conformance (106.04)	Maximum[1] chloride permeability	–	AASHTO T 277	1 set per test placement	Discharge stream at point of placement	Yes	Upon completing tests	–
		Compressive strength[3]	–	AASHTO T 23 & 22	"	"	"	"	–
		Tensile bond strength[9]	–	ASTM C1583	5 cores per test placement	In-place after curing is complete	"	"	–
HPC(O) and LMC	"	Density[6]	–	AASHTO T 121	1 per load	Point of discharge	No	Upon completing tests	–
		Air content[6]	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump[6][7]	–	AASHTO T 119	"	"	No	"	–
		Temperature	–	Field measured	"	"	No	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Aggregate (fine & coarse)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–
Production									
HPC(O)	Measured and tested for conformance (106.04)	Drying shrinkage[4] [5]	–	ASTM C157	Minimum 1 per 3000 ft^2 (280 m^2)	Point of discharge	No	Upon completing tests	–
HPC(O) & LMC	Statistical (106.05)	Maximum chloride permeability[1]	II	AASHTO T 277	1 set per 30 yd^3 (23 m^3), but not less than 1 per day	Discharge stream at point of placement	Yes	Upon completing tests	–
		Compressive strength[8]	II	AASHTO T 23 & T 22	"	"	"	"	–
		Tensile bond strength[9]	II	ASTM C1583	1 set per 3,000 ft^2 (280 m^2) of overlay, but not less than 1 per day	In-place after curing is complete	No	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
HPC(O) and LMC	Measured and tested for conformance (106.04)	Density[6]	–	AASHTO T 121	1 per load	Point of discharge	No	Upon completing tests	–
		Air content[6]	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump[6] [7]	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	ASTM C1064	"	"	"	"	–
Aggregate (fine & coarse)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes, when requested	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

(1) Cast at least three 4- by 8-inch (100- by 200-millimeter) maximum chloride permeability cylinders per set and carefully transport the cylinders to the job site curing facility. Cure the HPC(O) cylinders for 7 days and the LMC cylinders for 3 days according to AASHTO M 201. Then cure the HPC(O) cylinders at 100 °F ± 10 °F (38 °C ± 5 °C) in saturated lime water until AASHTO T 277 sample conditioning begins and air dry the LMC cylinders at 73 °F ± 3 °F (23 °C ± 2 °C) at 40 to 60 percent relative humidity. Test for chloride permeability at 28 days by measuring the total charge passed, in coulombs, over a specified period of time according to AASHTO T 277. The test result is the average of the measurements on three cylinders cast from the same load. If pigment is used in the concrete mixture, sample concrete at the batch plant before and after adding pigment. Test at least three specimens with and without pigment. Determine the average difference between the pigmented and non-pigmented test results. Adjust production test results by the average difference. Report both initial and adjusted test results.

(2) For HPC(O), cast at least fifteen 4- by 8-inch (100- by 200-millimeter) compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders each at 1, 3, 7, 14 and 28 days. A single compressive strength test result is the average result from three cylinders cast from the same load.

(3) For LMC, cast at least eighteen 4- by 8-inch (100- by 200-millimeter) compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders each at 1, 2, 4, 7, 14 and 28 days. A single compressive strength test result is the average result from three cylinders cast from the same load.

(4) Drying shrinkage testing is not required if the concrete mixture contains 1.5 gallons per cubic yard (7.5 liters per cubic meter) of an approved shrinkage reducing admixture.

(5) If testing is required, use 3- by 3- by 11-inch (75- by 75- by 275-millimeter) prisms for drying shrinkage specimens. Cast at least three drying shrinkage prisms per set and carefully transport the prisms to the job site curing facility. Moist cure the prisms for the duration of the specified moist curing period for HPC(O) elements. Measure for shrinkage in microstrains determined according to ASTM C157. The zero measurement is the initial measurement taken at demolding of the specimens at 23½±½ hours after introduction of mixing water to the concrete mixture. Determine percent drying shrinkage by measuring at the end of specified moist curing period for the structural elements, 1, 4, 7, 14, 28, and 56 days after the end of the specified field moist curing period. Drying shrinkage 28 days after the termination of moist curing (28 days drying) cannot exceed 60 percent of the maximum specified value shown in Table 569-1. The set drying shrinkage test result is the average result from three prisms cast from the same load.

(6) For LMC, measure density, slump, and plastic air content 5 minutes after discharge from the mixer chute. Cover wheelbarrow or other receptacle used to hold sample with a sheet of plastic to prevent evaporation during the 5 minutes before sampling.

(7) If reinforcing fibers are used at an addition rate greater than 0.3 percent by volume, measure slump at the batch plant before adding fibers.

(8) Cast at least six 4- by 8-inch (100- by 200-millimeter) compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders at 28 days. Remainder of cylinders to be used as designated by the CO.

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

(9) At random locations determined by the CO, core 2-inch (50-millimeter) diameter specimens through the overlay and ½ inch (13 millimeters) into the substrate concrete. Cure the specimens in situ for the same length of time as the overlay. Test the specimens in situ by attaching a loading disk with fast setting, high strength epoxy. Measure the tensile pull off bond strength in pounds per square inch (megapascals) according to ASTM C1583. The average bond strength is the average of the results from three test specimens adjusted as follows: For tests where failure occurs in the substrate concrete at a depth of ¼ inch (6 millimeters) or greater for more than 50 percent of the specimen, use 150 pounds per square inch (1 megapascal) for that specimen test result in the calculation of the average of the three test specimens. When two of the three test results have been adjusted, the average bond strength results shall be the greater of 150 pounds per square inch (1 megapascal) or the calculated value.	

DIVISION 600
INCIDENTAL CONSTRUCTION

Section 601. — MINOR CONCRETE STRUCTURES

Description

601.01 This work consists of constructing minor concrete structures.

Material

601.02 Conform to the following Subsections:

Air-entraining admixtures	711.02
Chemical admixtures	711.03
Coarse aggregate for concrete	703.02
Color coating	725.15
Concrete coloring agents	711.05
Curing material	711.01
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Pozzolans	725.04
Reinforcing fibers	725.17
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01
Water	725.01(a)

Construction Requirements

601.03 Composition (Concrete Mix Design). Conform to Table 601-1. Before batching concrete, submit the proposed concrete proportions for approval on FHWA Form 1606, *Minor Concrete Mix Design Trial Batch Summary* or other approved form. As a minimum, submit the following at least 30 days before production:

(a) Type and sources of material;

(b) Material certification for material;

(c) Saturated surface dry mass of the fine and coarse aggregate per cubic yard (cubic meter) of concrete;

(d) Gradation of fine and coarse aggregate;

(e) Mass of mixing water per cubic yard (cubic meter) of concrete;

(f) Mass of cement per cubic yard (cubic meter) of concrete. Fly ash, ground iron blast-furnace slag, or silica fume (micro-silica) may be substituted for cement according to Table 552-3;

(g) Entrained air content of plastic concrete in percent by volume;

(h) Maximum slump of plastic concrete in inches (millimeters); and

(i) When colored concrete is required, submit preliminary samples of the colored concrete. Prepare a 3-foot by 3-foot by 4-inch (1-meter by 1-meter by 100-millimeter) panel for each acceptable mix that is to be colored. Finish and cure the panels in the same manner as the concrete will be finished and cured on the project.

Table 601-1
Composition of Minor Concrete

Property	Specification
Cement content	611 pounds per cubic yard (362 kilograms per cubic meter) minimum
Water/cementitious material	0.49 maximum
Slump	5 inches (125 millimeters) maximum
Air content	4 % minimum
Size of coarse aggregate	AASHTO M 43 with 100% passing the 1½-inch (37.5-millimeter) sieve
28-day compressive strength	3,000 pounds per square inch (25 megapascal) minimum

601.04 General. Excavate and backfill according to Section 209. When concrete is cracked, spalling, or scaling, remove concrete to the nearest joint.

Design and construct forms that are free of bulge and warp and allow for removal without injuring the concrete. Design the forms for a lateral pressure equal to that exerted by a fluid weighing 150 pounds per cubic foot (2400 kilograms per cubic meter).

Use wood, metal, or other suitable material for forms. Keep forms clean and coat with a form release agent or form oil before placing concrete.

Place and fasten reinforcing steel according to Subsection 554.08.

601.05 Placing Concrete. Conform to Subsection 552.10. Moisten the forms and foundation immediately before placing concrete. Discharge concrete within the time limit shown in Table 552-4.

Place concrete to avoid segregation of material. Consolidate with vibrators according to Subsection 552.11(d). Do not use aluminum pipe for transporting or placing concrete. Do not exceed 30 minutes between deliveries of batches for a single pour on a structure.

Do not apply water to plastic concrete surfaces during finishing operations.

601.06 Curing Concrete. Cure concrete at least 7 days. If high early strength cement is used, cure concrete at least 3 days. Cure according to Subsection 552.15. Finish exposed concrete surfaces according to Subsection 552.16 as applicable.

601.07 Acceptance. Material for minor concrete structures including concrete, reinforcing steel, and structural steel for minor structures will be evaluated under Subsections 106.02 and 106.03.

Construction of minor concrete structures will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

601.08 Measure the Section 601 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When concrete is measured by the cubic yard (cubic meter), measure in the structure.

Payment

601.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 601 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for concrete lump sum bid item will be prorated based on the progress of the work under this Section.

Section 602. — CULVERTS AND DRAINS

Description

602.01 This work consists of furnishing and installing culverts, drains, and precast concrete box culverts.

Material

602.02 Conform to the following Sections and Subsections:

Asphalt mastic	702.04
Concrete pipe	706
Gaskets for concrete pipe	706.08
Gaskets for ductile iron pipe	707.18
Gaskets for metal pipe	707.17
Gaskets for plastic pipe	708.08
Lean concrete backfill	614
Metal pipe	707
Mortar	712.02
Plastic pipe	708
Precast concrete units and accessories	725.09
Precast reinforced concrete box sections	706.07
Sealants, fillers, and seals	712.01
Supplemental concrete pipe ties	706.09

Construction Requirements

602.03 General. Furnish culvert pipe with a wall thickness not less than that shown in the plans or determined from the fill-height tables included in the plans. Use the same material and coating on contiguous pipe sections and special sections (such as elbows and branch connections). For culvert extensions, furnish the same material as the existing culvert.

Plans show the size, length, and approximate location of culverts. Determine final location, skew, length, elevations, and grade according to Section 152. Do not order culvert material until the CO has accepted the final structure size, length, and alignment.

Construct cast-in-place concrete box culverts according to Section 552. For precast concrete box culverts, submit design drawings and details with supporting calculations according to Subsection 104.03.

Excavate and backfill according to Section 209.

Place elongated pipes with the minor axis within 5 degrees of vertical.

Construct a piping plug unless the culvert inlet is protected with a full-height headwall, slope paving, or an embankment consisting of AASHTO M 145 classification A-6 or A-7 material. Construct the piping plug with AASHTO M 145 classification A-6, A-7, or other approved material with a permeability not exceeding 0.004 inches (0.1 millimeters) per second.

602.04 Laying Concrete Pipe and Precast Concrete Box Culverts. Start at the lower end and lay the bell or groove end upgrade. Fully join sections with leak-resistant seals using one of the following methods:

(a) Mortared joints. Clean the lower portion of the receiving end of the pipe. Plaster the inside with sufficient joint mortar to bring the inner surfaces of the abutting pipe sections flush and even. Fit the sections as close as the construction of the culvert permits. Fill and seal joints with mortar inside and out. Use the mortar within 30 minutes after mixing. Clean excess mortar from the inside of the joint.

Cure mortar outside of joints by covering with polyethylene sheeting or spraying with a curing compound. Backfill while mortar is plastic or, if mortar sets before backfilling, wait at least 24 hours before backfilling.

(b) Gasket joints. Conform to ASTM C990 or ASTM C443 and the following:

(1) Protect the joint ends from mud, silt, gravel, or other foreign material. Lay the pipe sections with gaskets attached. Remove, clean, relubricate, and reseat gaskets disturbed or contaminated.

(2) Align the pipe sections. Force the joints home using the pipe manufacturer’s recommended procedure. Do not drive or ram by hand or machinery. Block the last section of each day's run to prevent creep.

Install supplemental concrete pipe ties on the last downstream pipe-to-pipe joint and at the downstream pipe-to-end section joint, if present.

602.05 Laying Metal Pipe. Position the pipe with a longitudinal joint so the joint is opposite the invert. Fully join pipe sections with leak-resistant seals according to AASHTO M 36 or AASHTO M 196. Use one of the following:

(a) Gasket, bell and spigot joints. Use on slopes of 10 percent or less and lay the pipe with the bell end up slope.

(b) Coupling bands with gaskets. Limit the use of coupling bands with projections (dimples) to attaching prefabricated flared end sections.

When aluminum alloys come in contact with other metals, coat the contacting surfaces with asphalt mastic or a preapproved impregnated caulking compound.

602.06 Laying Plastic Pipe. Lay plastic pipe according to the pipe manufacturer’s recommendation.

Fully join pipe sections with leak-resistant seals using gasket, bell and spigot joints according to ASTM D3212.

602.07 Laying Slotted Drain Pipe. Fully join pipe sections with leak-resistant seals using coupling bands and gaskets. Cover the slots with roofing paper or other approved covering during backfilling and paving to keep material out of the pipe. Backfill with a lean concrete backfill.

602.08 Acceptance. Material for culverts, drains, and precast concrete box culverts furnished will be evaluated under Subsections 106.02 and 106.03.

Installation of culverts, drains and precast concrete box culverts will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

602.09 Measure the Section 602 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring pipe and box culverts by the linear foot (meter), measure along the invert.

Measure end sections, elbows, and branch connections by the each. If there is no pay item for elbows or branch connections, measure them as additional pipe length along the invert.

Measure pipe anchor assemblies under Section 606.

Payment

602.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 602 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 603. — STRUCTURAL PLATE STRUCTURES

Description

603.01 This work consists of constructing structural plate pipes, arches, pipe arches, boxes, and underpasses.

Material

603.02 Conform to the following Subsections:

Aluminum-alloy structural plate structures	707.06
Asphalt-coated structural plate structures	707.07
Steel structural plate structures	707.05

Construction Requirements

603.03 General. Excavate and backfill according to Section 209.

603.04 Erecting. Furnish steel, aluminum alloy, asphalt coated steel, or asphalt-coated aluminum alloy structural plate structures.

Submit a copy of manufacturer's assembly instructions before assembly. Show the position of each plate and assembly order.

Assemble the structural plates according to the manufacturer's instructions. Exercise care in the use of drift pins and pry bars to prevent damage to the structural plate and its coating. Clear sand, gravel, and other foreign material from the corrugations within lapped sections of the plates. Ensure plates have a proper fit-up.

Where aluminum alloys come in contact with other types of metal, coat the contacting surfaces according to Subsection 602.05.

Torque steel bolts on steel plates to at least 100 foot-pounds (135 newton-meters) and a maximum of 300 foot-pounds (400 newton-meters).

Torque steel bolts and aluminum bolts on 0.1-inch (2.5-millimeter) thick aluminum plates to at least 90 foot-pounds (120 newton-meters) and a maximum of 115 foot-pounds (155 newton-meters).

Torque steel bolts and aluminum bolts on 0.1-inch (2.5-millimeter) thick and heavier aluminum plates to at least 90 foot-pounds (155 newton-meters) and a maximum of 115 foot-pounds (180 newton-meters).

For long-span structures:

(a) Tighten the longitudinal seams when the plates are assembled unless the plates are held in shape by cables, struts, or backfill. Properly align plates circumferentially to avoid permanent distortion from the design shape. Before backfilling, do not exceed 2 percent variation from the design shape.

(b) Do not distort the shape of the structure by operating equipment over or near it.

(c) Provide suitable survey control on the structure to check structure movement.

(d) Check and control the deflection movements of the structure during the entire backfilling operation. Do not exceed the manufacturer's recommended limits.

(e) Provide a manufacturer's representative to monitor the erecting and backfilling of the structure.

603.05 Acceptance. Material for structural plate structures will be evaluated under Subsections 106.02 and 106.03.

Installation of structural plate structures will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

603.06 Measure the Section 603 pay items listed in the bid schedule according to Subsection 109.02.

Payment

603.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 603 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 604. — MANHOLES, INLETS, AND CATCH BASINS

Description

604.01 This work consists of constructing, adjusting, shifting, or modifying manholes, inlets, and catch basins.

Material

604.02 Conform to the following Section and Subsections:

Concrete building brick	725.06
Concrete masonry units	725.07
Corrugated metal units	725.11
Frames, grates, covers, and ladder rungs	725.10
Gaskets for concrete pipe	706.08
Gaskets for metal pipe	707.17
Minor concrete	601
Mortar	712.02
Neat hydraulic cement grout	725.13(a)(2)
Reinforced concrete manhole sections	725.09(a)
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01

Construction Requirements

604.03 General. Excavate and backfill according to Section 209.

Separate catch basins and inlets from adjacent concrete structures with at least ½-inch (13-millimeter) thick preformed expansion joint.

Construct minor concrete according to Section 601.

604.04 Concrete Construction. Concrete units may be cast-in-place or precast. Finish surfaces according to Subsection 552.16 as applicable.

Finish the flow line in manholes, inlets, and catch basins to match the pipe flow line.

Assemble precast concrete manhole sections with flexible gaskets or fillers in the tongue and groove joints. Handle the precast units carefully after the gasket has been attached to avoid damaging the gasket or contaminating the joint. Attain the proper alignment before the joints are forced home. Ensure gasket is uniformly seated. Apply mastic joint filler according to manufacturer’s recommendations if mastic is used.

Set metal frames in a full mortar bed.

Space ladder rungs uniformly on 12-inch (300-millimeter) centers and align vertically. Grout ladder rungs into precast concrete walls.

604.05 Concrete Masonry Unit Construction. Construct masonry block plumb. Stagger vertical joints and set block with the cells vertical. Moisten blocks before using in work. Butter bearing members and vertical joints full of mortar. Bond block with mortar on sides. Construct joints straight, level, plumb, flush, and ¼ to ½ inch (6 to 13 millimeters) thick. Backfill the structure after the masonry block joints have moist cured for 7 days.

604.06 Metal Construction. Fabricate metal drop inlets from the same material and thickness as adjoining metal pipes. Connect metal inlets to adjoining metal pipes according to Subsection 602.05.

604.07 Grade Adjustment of Structures. Adjust metal frames and grates to grade before placing the surface course.

Remove and clean the frames, covers, and grates. Trim the walls down to solid material. Reconstruct the walls with the same material as existing and reset the cleaned frames at the required elevation.

When the existing casting and supporting walls are in good condition, an approved device may be used to adjust the manhole casting cover to the correct grade.

Clean each structure of foreign material.

604.08 Shifting and Modifying Structures. Shift structures using methods to ensure structural integrity. Reshape the channel flow line in manholes, inlets, and catch basins as necessary to match the pipe flow line.

Set and reassemble structures according to the applicable requirements of Subsections 604.04 through 604.07. Furnish and install gaskets, seals, and other accessories according to the applicable requirements of Subsections 604.04 through 604.06. Grout or use a preformed joint seal to make joints and openings leak resistant. Finish mortar joints with a bead on the outside and a smooth finish on the inside.

When modifying a concrete structure, do not cut the concrete and reinforcing steel in a manner that loosen the reinforcement in the wall. Cut the reinforcing steel flush with the opening wall face. Grout joints and openings cut in the wall.

Seal openings no longer required in the structure.

When an existing structure is abandoned, seal pipes entering the structure with a tight fitting plug of concrete at least 6 inches (150 millimeters) thick or water tight masonry at least 8 inches (200 millimeters) thick. Ensure the structure does not entrap water. Obliterate the top of the structure to an elevation at least 36 inches (900 millimeters) below finished grade and backfill according to Section 209.

604.09 Acceptance. Material for metal, concrete brick, concrete masonry, precast concrete units, and cast-in-place concrete (except concrete) units will be evaluated under Subsections 106.02 and 106.03. Concrete for cast-in-place concrete units will be evaluated under Section 601.

Construction of metal, concrete brick, concrete masonry, and cast-in-place concrete units will be evaluated under Subsections 106.02 and 106.04.

Installation of precast concrete units will be evaluated under Subsections 106.02 and 106.04.

Shifting, modifying, and adjusting units will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

604.10 Measure the Section 604 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When manholes are measured by the linear foot (meter), measure from finished grade to the flow line surface of the manhole.

Do not measure metal frames and grates when included as part of the original inlet, manhole, or catch basin construction.

Payment

604.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 604 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 605. — UNDERDRAINS, SHEET DRAINS, AND PAVEMENT EDGE DRAINS

Description

605.01 This work consists of furnishing and installing underdrains, sheet drains, and pavement edge drains.

Geotextile filter is designated according to Table 714-1.

Material

605.02 Conform to the following Section and Subsections:

Aluminum-alloy corrugated pipe	707.03
Asphalt-coated pipe	707.04
Geocomposite drain	714.02
Geotextile	714.01
Granular backfill	703.03
Metallic-coated corrugated steel pipe	707.02
Perforated concrete pipe	706.03
Plastic pipe	708
Sand	703.14
Structural backfill	704.04

Construction Requirements

605.03 General. Elevate and protect sheets, panels, or rolls of geotextile filter and geocomposite with a waterproof and ultraviolet resistant cover if stored outdoors. Limit geotextile filter and geocomposite exposure to less than 10 days when using for a permanent installation.

Use the same material and coating on contiguous drain sections, extensions, elbows, branch connections, and other special sections.

Drain material, size, and approximate location are shown in the plans. Determine the final location and length in the field.

Do not install drain material until the CO has accepted the final location and length.

Excavate and backfill according to Section 209.

If geotextile filter or geocomposite is used, smooth the trench surfaces by removing projections that may damage the geotextile filter or geocomposite. Replace geotextile filter or geocomposite damaged during installation.

Do not allow soil or other foreign material to enter the drain systems. Plug the upgrade end of installations.

Furnish nonperforated pipe for outlet pipe. Install outlet pipe according to Section 602. Immediately place and secure a screen made of 0.055-inch (1.4-millimeter) diameter galvanized wire having approximately ½- by ½-inch (13- by 13-millimeter) mesh openings over the outlet ends of exposed pipes and weep holes.

605.04 Placing Underdrain. Join pipe sections securely with coupling fittings or bands. Join PVC and acrylonitrile-butadiene-styrene (ABS) pipe using either a flexible elastomeric seal or solvent cement. Join polyethylene pipe with snap-on, screw-on, or wrap around coupling bands as recommended by the manufacturer.

Backfill and compact trenches within the limits of the roadbed according to Section 209, except use granular backfill material. Trenches for geocomposite underdrains within the limits of the roadbed may also be backfilled with sand and compacted.

When underdrain is placed in ditch lines, prevent infiltration of surface water by placing material conforming to AASHTO M 145, classification A-4, A-5, A-6, or A-7 in the top 12 inches (300 millimeter) of the trench.

(a) Standard underdrain. Place the long dimension of the geotextile filter parallel to the centerline of the trench. Position the geotextile filter, without stretching, in contact with the trench surface. Overlap the joints at least 24 inches (600 millimeter) with the upstream geotextile filter placed over the downstream geotextile filter.

Place collector pipe with the perforations facing downward.

Place granular backfill to a height of 12 inches (300 millimeter) above the top of the collector pipe and compact. Do not displace the collector pipe. Place and compact the remainder of the granular backfill material according to Section 209.

Fold the geotextile filter over the top of the granular backfill with a minimum overlap of 12 inches (300 millimeter).

(b) Geocomposite underdrain. Extend the geotextile filter from the bottom of the drainage core around the collector pipe.

Construct splices and install outlet fittings according to the manufacturer’s recommendations. Prevent infiltration of soil into the geocomposite core.

Place the assembled geocomposite in the trench with the face of the geocomposite against the inflow side of the trench. If the trench wall is irregular, smooth the trench wall or place a layer of granular backfill between the geocomposite and the trench wall. Temporarily support the drain against the trench wall while backfilling.

When the trench is less than 18 inches (450 millimeter) wide, backfill the trench using sand. Backfilling and compacting in layers is not required. Compact the sand by vibrating or tamping with a mechanical tamper.

When the trench is equal to or greater than 18 inches (450 millimeter) wide, place granular backfill or sand to a height of 12 inches (300 millimeter) above the top of the collector pipe and compact. Place and compact the remainder of the granular backfill material or sand according to Section 209.

For pipe drain installations draining directly to daylight, cover the outlet end of the pipe with a removable screen made of 0.055-inch (1.4-millimeter) diameter galvanized wires having approximate ½- by ½-inch (13- by 13-millimeter) mesh openings.

605.05 Placing Geocomposite Sheet Drain. Do not place sheet drain against a mortar course less than 4 days old.

When a geocomposite is used in conjunction with a waterproof membrane, install drainage panels compatible with the membrane using methods recommended by the membrane manufacturer. Assemble and place the geocomposite drain against the surface to be backfilled according to the manufacturer's recommendations.

Splice geocomposite drains so the flow across the edges is continuous. Overlap the geotextile filter at least 3 inches (75 millimeter) in the direction of water flow. For vertical splices, overlap the geotextile filter in the direction backfill proceeds.

Connect the drainage core to the collector pipe or weep holes so the flow is continuous through the system. Extend the geotextile filter from the bottom of the drainage core around the collector pipe.

Backfill with structural backfill and compact according to Subsections 209.09 and 209.10.

605.06 Placing Geocomposite Pavement Edge Drain. Assemble the geocomposite pavement edge drain and outlet material according to the manufacturer's recommendations and place it in the trench. If the trench wall is irregular, smooth the trench wall or place a layer of sand between the geocomposite and the trench wall. Temporarily support the drain against the trench wall while backfilling.

When the trench is less than 18 inches (450 millimeter) wide, backfill the trench using sand. Backfilling and compacting in layers is not required. Compact the sand by vibrating or tamping with a mechanical tamper.

When the trench is 18 inches (450 millimeter) wide or more, place and compact granular backfill or sand according to Section 209.

605.07 Acceptance. See Table 605-1 for sampling, testing, and acceptance requirements.

Material (except granular backfill) for underdrains, sheet drains, and edge drains will be evaluated under Subsections 106.02 and 106.03.

Granular backfill will be evaluated under Subsections 106.02 and 106.04.

Geocomposites will be evaluated under Subsection 106.03. Submit a production certification with each shipment of geocomposite that includes the name of the manufacturer, product name, style number, chemical composition of the core and encapsulating geotextile filaments or yarns, and other pertinent information to fully describe the geocomposite drain.

Installation of underdrains, sheet drains, and edge drains will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Sections 208 and 209.

Geotextile filter will be evaluated under Section 207.

Outlet pipes will be evaluated under Section 602.

Measurement

605.08 Measure the Section 605 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measurement is for a system, do not measure geotextile filters, geocomposites, collector pipes, backfill, and outlet pipes that are part of the system.

When measuring granular backfill and sand by the cubic yard (cubic meter), measure in place.

Payment

605.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 605 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 605-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Granular backfill (703.03)	Measured and tested for conformance (106.04 & 105)	Quality	–	Subsection 703.03	1 per aggregate type and source of material	Source of material	Yes	Before using in work	Not required when using Government-provided source
Production									
Granular backfill (703.03)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3 (460 m^3)	Production output or stockpile	Yes	4 hours	–

Section 606. — CORRUGATED METAL SPILLWAYS

Description

606.01 This work consists of furnishing and installing corrugated metal spillways.

Material

606.02 Conform to the following Section:

Culverts and drains	602

Construction Requirements

606.03 Placing Corrugated Metal Spillways. Spillway, inlet, outlet, and connector dimensions and proportions may vary to permit the use of manufacturer's standard jigs and templates.

Install spillway inlet assemblies as shown in the plans and consolidate the earth backfill by tamping.

Lay spillway outlet pipe according to Section 602. Anchor the spillway as shown in the plans.

606.04 Acceptance. Pipes, anchor assemblies, hardware, and other material furnished to fabricate metal spillways will be evaluated under Subsections 106.02 and 106.03.

Construction of corrugated metal spillways will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

606.05 Measure the Section 606 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure downdrain and outlet pipes under Section 602.

Payment

606.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 606 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 607. — CLEANING, RELAYING, AND REPAIRING EXISTING DRAINAGE STRUCTURES

Description

607.01 This work consists of cleaning, relaying, and repairing existing drainage and appurtenant structures.

Construction Requirements

607.02 Cleaning Drainage Structures in Place. Remove foreign material within the structure and accessories by approved methods.

Remove debris, vegetation, and earthen material that impedes inlet and outlet channel flow to the structure. Obtain approval from the CO before removing trees.

Dispose of removed material according to Subsection 203.05.

Regrade inlet and outlet channels at structures to provide positive drainage. Reshape inlet to direct flow into the structure entrance.

607.03 Relaying or Stockpiling Salvaged Pipe. Relay removed and cleaned pipe according to Section 602.

Salvage and stockpile pipe according to Subsection 203.03.

Replace damaged pipe and install according to Section 602. Dispose of damaged pipe according to Subsection 203.05(a).

607.04 Repairing Drainage Structures. Remove debris from structures designated to be repaired. Repair leaks and structural damage and replace missing or broken metalwork according to Sections 602 and 603.

607.05 Acceptance. Cleaning and repairing existing drainage structures will be evaluated under Subsection 106.02.

Relaying pipe will be evaluated under Section 602.

Measurement

607.06 Measure the Section 607 pay items listed in the bid schedule according to Subsection 109.02.

Payment

607.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 607 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 608. — PAVED WATERWAYS

Description

608.01 This work consists of constructing paved waterways not contiguous to the traveled way.

Paved waterways are designated as follows:

Type 1 – Grouted rubble

Type 2 – Mortared rubble

Type 3 – Concrete and rubble

Type 4 – Concrete

Type 5 – Asphalt

Material

608.02 Conform to the following Sections and Subsections:

Asphalt concrete	403
Bedding material	704.02
Minor concrete	601
Mortar	712.02
Neat hydraulic cement grout	725.13(a)(2)
Reinforcing steel	709.01
Rock for masonry structures (rubble)	705.03
Sand	703.14

Construction Requirements

608.03 General. Excavate and backfill according to Section 209. Place and compact the bedding material with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

608.04 Grouted Rubble Paved Waterway (Type 1). Clean and wet the rubble to near saturation. Set rubble in a broken pattern with no continuous joint across the waterway or parallel to the flow line. Place rubble into the mortar bed with the flat faces up and the longest dimension at right angles to the flow line. Make the joints 1 to 2 inches (25 to 50 millimeters) wide.

Ram each piece of rubble until it is firm and true to the surface in grade, alignment, and cross-section. Remove and relay rubble having an irregular or uneven surface.

Fill the joints with sand to within 4 inches (100 millimeters) of the surface. Pour and broom grout into the joints until the grout is ½ inch (13 millimeters) below the surface of the rubble. Clean excess grout from the rubble surface.

608.05 Mortared Rubble Paved Waterway (Type 2). Clean and wet the rubble to near saturation. Set rubble in a broken pattern with no continuous joint across the waterway or parallel to the flow line. Place rubble into the mortar bed with the flat face up and the longest dimension parallel to the flow line. Make joints 1 to 2 inches (25 to 50 millimeters) wide.

Ram each piece of rubble until it is firm and true to the surface in grade, alignment, and cross-section. Remove and relay rubble having an irregular or uneven surface.

Fill joints to within ½ inch (13 millimeters) below the surface of the rubble. Clean excess mortar from the rubble surface.

608.06 Concrete and Rubble Paved Waterway (Type 3). Perform concrete work according to Section 601. Secure the reinforcing steel within the middle third of the depth of the concrete foundation when required.

Clean and wet the rubble to near saturation. Embed rubble into the concrete foundation in a broken pattern with no continuous joint across the waterway or parallel to the flow line.

Make the joints 1 to 2 inches (25 to 50 millimeters) wide. Fill the joints with mortar to 1 inch (25 millimeters) below the surface of the rubble. Clean excess mortar from the rubble surface.

608.07 Concrete Paved Waterway (Type 4). Perform the work according to Section 601.

608.08 Asphalt Paved Waterway (Type 5). Perform the work according to Section 403. Clean and seal the cracks according to Section 414 before overlaying existing asphalt paved waterway.

608.09 Acceptance. See Table 608-1 for sampling, testing, and acceptance requirements.

Material for grout and mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsection 106.04.

Bedding material and sand will be evaluated under Subsections 106.02 and 106.04.

Construction of paved waterways will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Asphalt concrete will be evaluated under Section 403.

Minor concrete will be evaluated under Section 601.

Rubble will be evaluated under Section 620.

Measurement

608.10 Measure the Section 608 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring the area, measure the width horizontally to include the total width. Measure the length parallel to the flow line.

When measuring paved waterway lengths, measure from the front face of the curb along the flow line of the paved waterway.

Payment

608.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 608 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 608-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Bedding material (704.02)	Measured and tested for conformance (106.04 & 105)	Gradation	–	Subsection 704.02	1 per soil type and source of material	Source of material	Yes	Before using in work	Not required when using Government-provided source
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Sand (703.14)	"	Gradation & deleterious material	–	AASHTO M 6	"	"	"	"	"
Production									
Bedding material (704.02)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3 (500 m^3)	Production output or stockpile	Yes	4 hours	"
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Sand (703.14)	"	Gradation	–	AASHTO T 27 & T 11	"	"	"	"	"

Section 609. — CURB AND GUTTER

Description

609.01 This work consists of constructing or resetting curb, combination curb and gutter, or wheelstops.

Material

609.02 Conform to the following Sections and Subsections:

Asphalt concrete	403
Bedding material	704.02
Concrete coloring agents	711.05
Minor concrete	601
Mortar	712.02
Reinforcing steel	709.01
Rock for masonry structures (stone curbing)	705.03
Sealants, fillers, and seals	712.01

Construction Requirements

609.03 General. Excavate and backfill according to Section 209. Place and compact the bedding material. Compact the bedding material with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

609.04 Stone and Precast Concrete Curb. Do not use stone with visible drill marks on the exposed faces.

Conform to the dimensions of stone curb specified and the following:

(a) Type 1. Saw or point the top surface of vertical stone curb to an approximate true plane with no depression or projection on that surface of over ¼ inch (6 millimeters). Pitch the front and back arris lines straight and true. Limit projections or depressions on the back surface to not exceed a batter of 1 inch (25 millimeters) horizontal to 3 inches (75 millimeters) vertical.

Saw, point, or smooth quarry split the front exposed face of the vertical stone curb and form to an approximately true plane. Limit projections or depressions on the remaining face distance to 1 inch (25 millimeters) or less from the plane of the exposed face.

Square the ends of vertical stone curb with the top back and face and finish so when the sections are placed end to end, shows no space more than ½ inch (13 millimeters) in the joint for the full width of the top surface and for the entire exposed front face. The remainder of the end may break back no more than 4 inches (100 millimeters) from the plane of the joint. Cut the joints of circular or curved stone curb on radial lines.

Make stone curb segments at least 48 inches (1200 millimeters) long, but the length may vary where a depressed or modified section of curb is required for driveways, crossings, or closures.

(b) Type 2. Conform to the requirements of Type 1 stone curb for slope stone curb, except as follows:

The maximum allowable projection or depression on a horizontal top surface is limited to ½ inch (13 millimeters). On other exposed faces, the maximum allowable projection or depression is limited to 1 inch (25 millimeters).

For unexposed surfaces, the maximum allowable projection or depression from a true plane on a 24-inch (600-millimeter) length is 3 inches (75 millimeters).

The maximum allowable space showing on exposed faces between adjacent segments of slope stone curb is ¾ inch (19 millimeters). Make slope stone curb segments at least 24 inches (600 millimeters) long.

Clean the curb material thoroughly and wet it just before setting. Set the curb in bedding material so the face and top lines are to line and grade. Make the joints ½ to 1 inch (13 to 25 millimeters) wide and fill the joints with mortar.

Complete the first 25 feet (8 meters) of curb to demonstrate the ability to build a curb conforming to these requirements. Do not continue construction until the 25-foot (8-meter) test section is approved.

Where a concrete pavement is constructed contiguous to the curb, construct the joints in the curb directly in line with the pavement expansion joints.

Make the curb joint ¾ inch (19 millimeters) wide and fill it with expansion joint filler of the same nominal thickness as the pavement joint. Fill voids between the joint filler and the curb with mortar.

609.05 Concrete Curb or Curb and Gutter. Perform work according to Section 601. The curb or curb and gutter may be cast-in-place or slip-formed.

(a) Cast-in-place. Use forms that extend for the full depth of the concrete. Use curved forms for curb with a radius of 300 feet (90 meters) or less.

(1) Contraction joints. Construct curb in sections of uniform 10-foot (3-meter) lengths. Construct contraction joints ⅛ inch (3 millimeters) wide. Use metal divider plates. When the curb is constructed adjacent to or on concrete pavement, match the contraction joints in the pavement.

(2) Expansion joints. Form expansion joints at intervals of 60 feet (18 meters) using a ¾-inch (19-millimeter) thick preformed expansion joint filler. Where the curb is constructed adjacent to or on rigid pavement, match the expansion joints in the pavement.

Finish the concrete smooth and even with a wood float. Broom finish parallel to the curb line according to Subsection 552.14(c)(2). When an exposed aggregate finish is required, finish according to Subsection 552.14(c)(4). Leave forms in place for 24 hours or until the concrete has set sufficiently so the forms can be removed without harming the curb.

(b) Slip-formed. Use a self-propelled automatic curb machine or a paver with curb attachments. Use a machine that is heavy enough to obtain consolidation without the machine riding above the foundation.

Adjust the concrete aggregate gradation, if necessary, to produce a curb or curb and gutter that has well defined web marks of water on the surface. Remove and replace sections with craters larger than $^{3}/_{16}$ inch (5 millimeters) or other sections determined to be damaged or defective. Repairing surface craters and other defective sections by plastering is not permitted.

After the concrete has hardened sufficiently to permit sawing without damage, saw contraction joints according to Subsection 609.05(a)(1). Construct expansion joints according to Subsection 609.05(a)(2).

609.06 Asphalt Concrete Curb. Where curb is constructed on a pavement, place a tack coat according to Section 412 on the area under the curb.

Construct asphalt concrete curb according to Section 403. Use a self-propelled automatic curb machine or a paver with curb attachments that is heavy enough to compact a curb without riding above the foundation. Make the curb uniform in texture, shape, and density. Curb may be constructed by other means only in short sections or sections with short radii.

609.07 Resetting Stone or Precast Concrete Curb. Carefully remove, clean, and store the curb. Cut or fit the curb as necessary for installation. Replace lost, damaged, or destroyed curb. Reset the curb according to Subsection 609.04.

609.08 Wheelstops. Pin the wheelstops in place with two 36-inch (900-millimeter) sections of No. 6 (19M) reinforcing steel or ¾-inch (19-millimeter) steel rods. Reset wheelstops in the same manner.

609.09 Acceptance. See Table 609-1 for sampling, testing, acceptance requirements.

Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsection 106.04.

Precast units (curb and wheel stops) will be evaluated under Subsections 106.02 and 106.03.

Bedding material will be evaluated under Subsections 106.02 and 106.04.

Stone for stone curbing will be evaluated under Subsections 106.02 and 106.04.

Construction of curb and gutter, and wheelstops will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Asphalt concrete will be evaluated under Section 403.

Minor concrete will be evaluated under Section 601.

Measurement

609.10 Measure the Section 609 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring for curb or curb and gutter, make no deduction in length for drainage structures installed in the curb section or for driveway and handicap access ramp openings where the gutter is continuous across the opening.

Payment

609.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 609 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 609-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Bedding material (704.02)	Measured and tested for conformance (106.04 & 105)	Gradation	–	Subsection 704.02	1 per soil type and source of material	Source of material	Yes	Before using in work	Not required when using Government-provided source
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Production									
Bedding material (704.02)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3 (500 m^3)	Production output or stockpile	Yes	4 hours	–
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–

Section 610. — HORIZONTAL DRAINS

Description

610.01 This work consists of constructing horizontal drains, including collector systems.

Material

610.02 Conform to the following Subsection:

Horizontal drains	708.05(d)

Construction Requirements

610.03 Qualifications. Provide on-site supervisors and installation personnel with experience installing and testing horizontal drains. Submit the following for approval at least 30 days before starting work:

(a) Names of personnel; and

(b) A résumé for each individual describing their experience on at least five horizontal drain projects of similar complexity over the past 5 years. Include project names, locations, and contact information for project owners.

610.04 General. Verify location, elevation, spacing, and orientation of the horizontal drains installation.

Furnish pipe and fittings with a minimum outside diameter of 1½ inches (38 millimeters) or as specified. Furnish slotted pipe with three rows of slots cut circumferentially in the pipe 120 degrees apart. Make the width of the slots 0.01 inches (0.25 millimeters), with the total slot opening area equal to 0.46 square inches per foot (0.0003 square meters per meter) of pipe. Material for couplings, cleanouts, elbows, and other fixtures required for collection of water are to be compatible with the installed drain pipe.

The locations for installing horizontal drains as shown in the plans are approximate. The exact locations will be determined by the CO. Pipe drains that begin more than 12 inches (300 millimeters) or end more than 3.5 feet per 100 foot (1.1 meter per 30 meter) installed pipe from their planned locations, damaged in construction, or are improperly installed will be rejected by the CO.

610.05 Drilling Holes. Drill holes with rotary equipment capable of drilling 3- to 6-inch (75- to 150-millimeter) diameter holes up to 600 feet (180 meters) to designated lines and grades through soil and rock formations. Keep a log of material types, production rates, and estimated water flows encountered during drilling. Install horizontal drains as shown in the plans. During drilling operations, determine the elevation of the drilled hole at 100-foot (30-meter) intervals and at the upper end of the completed horizontal drain hole by inserting tubes or pipes and measuring liquid levels or by other approved means.

Dispose of drilling water and water encountered during drilling according to Federal, state, and local regulations.

610.06 Installing Horizontal Drain. Tightly plug the entrance end of the slotted pipe with a rounded or pointed extension that does not extend more than 6 inches (150 millimeters) beyond the end of the pipe. Insert the pipe inside the drill rod and then retract the drill rod so the drilled hole is cased with the slotted pipe for the full drilled depth. Connect additional pipe as necessary to form a continuous tube.

Use un-slotted pipe for the last 20 feet (6 meters) at the outlet end. Seal the space between the drilled hole and the un-slotted pipe for at least 10 feet (3 meters) at the outlet end with an approved impermeable material. Do not seal the space between the drilled hole and the slotted pipe.

610.07 Installing Outlet Drains and Collector Systems. Attach outlet drain pipe to the ends of horizontal drains by a tee or street ell. Install a collector system of the type, kind, and size as shown in the plans.

For pipe drain installations draining directly to daylight, cover the outlet end of the pipe with a removable screen made of 0.055-inch (1.4-millimeter) diameter galvanized wires having approximate ½- by ½-inch (13- by 13-millimeter) mesh openings.

610.08 Acceptance. Material furnished for horizontal drains will be evaluated under Subsections 106.02 and 106.03.

Construction of horizontal drains will be evaluated under Subsections 106.02 and 106.04.

Measurement

610.09 Measure the Section 610 pay items listed in the bid schedule according to Subsection 109.02.

Payment

610.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 610 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 611. — WATER SYSTEMS

Description

611.01 This work consists of constructing or reconstructing water systems.

Material

611.02 Conform to the following Subsections:

Bedding material	704.02
Seamless copper water tube and fittings	707.16
Smooth wall polyethylene (PE) pipe (for water distribution systems)	708.01
Smooth wall polyvinyl chloride pipe (for water distribution systems)	708.05
Steel pipe	717.06

Construction Requirements

611.03 General. Conform to the standards of APWA, the AWWA, *International Building Code* and local/agency plumbing and safety codes.

Submit at the preconstruction conference, a certified cost breakdown by individual items when water systems are paid the lump sum item for use in making progress payments and price adjustments.

Obtain permits, arrange for inspections, and pay fees necessary to obtain water service.

Excavate according to Section 209. Bed the pipe according to Subsection 209.08(b).

Coordinate service interruptions with the user or owner of the waterline. Provide temporary waterlines to ensure a water supply is maintained. Connection work may be required during times other than normal working hours. Do not stop work on a connection until it is completed.

Dispose of disinfectant for water lines according to Subsection 107.01. Do not dispose of disinfectant in a manner that could enter a body of water.

611.04 Backfilling. Backfill according to Subsection 209.09, except hand-place the backfill to a depth of 12 inches (300 millimeters) above the top of the pipe. Remove rocks and hard lumps from the hand-placed layer.

611.05 Acceptance. Material for water systems will be evaluated under Subsections 106.02 and 106.03.

Installation of water systems will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

611.06 Measure the Section 611 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring waterlines and encasement pipes, measure along the flow line including the length through tees, bends, valves, or other fixtures.

Payment

611.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 611 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for lump sum pay items will be prorated based on the total work completed.

Section 612. — SANITARY SEWER SYSTEMS

Description

612.01 This work consists of constructing sanitary sewer systems.

Material

612.02 Conform to the following Section and Subsections.

Bedding material	704.02
Cast iron soil pipe and fittings	707.15
Concrete water and waste water structures	725.09(e)
Plastic pipe	708

Construction Requirements

612.03 General. Furnish either cast iron or plastic sanitary sewer lines. Furnish material and workmanship conforming to the standards of the AWWA, *International Building Code* and local/agency plumbing and safety codes.

Submit at the preconstruction conference, a certified cost breakdown by individual items when sanitary sewer systems are paid the lump sum item for use in making progress payments and price adjustments.

Obtain permits, arrange for inspections, and pay fees necessary to obtain sewerage service.

Excavate according to Section 209. Bed the pipe according to Subsection 209.08(b).

Coordinate service interruptions with the user or owner of the sewerline. Provide temporary sewerlines to ensure a sewer supply is maintained. Connection work may be required during times other than normal working hours. Do not stop work on a connection until it is completed.

Dispose of disinfectant for sewer lines according to Subsection 107.01. Do not dispose of disinfectant in a manner that could enter a body of water.

612.04 Laying Sewer Lines. Inspect each joint and clean the pipe and bell before placing in the trench. Lay the sewer line from the lower end with the spigot ends pointing in the direction of flow. Fully support each length between joints and check for line and grade before placing the next length.

Check the gasket for proper positioning and shove sewer pipe into proper position where premolded watertight gaskets are used.

Position the pipe and fill the joint completely with joint sealer when poured joints are used. Allow the sealer to cool completely before removing the runner.

612.05 Backfilling. Backfill according to Subsection 611.04. Flush the lines with water to ensure they are unobstructed after backfilling.

612.06 Acceptance. Material for sanitary sewer systems will be evaluated under Subsections 106.02 and 106.03.

Installation of sanitary sewer systems will be evaluated under Subsections 106.02 and 106.04.

Excavation will be evaluated under Section 209.

Backfilling will be evaluated under Subsection 611.04.

Measurement

612.07 Measure the Section 612 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring sewer lines, measure along the flow line including the length through valves, ells, tees, valve boxes, reducers, manholes, or other fixtures. Where two different sizes enter or exit a manhole, measure each size to the center of the manhole.

Payment

612.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 612 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for lump sum pay items will be prorated based on the total work completed.

Section 613. — SIMULATED STONE MASONRY SURFACE

Description

613.01 This work consists of using concrete, color/stain, and grout to simulate the texture and color of native stone masonry in the stone pattern shown in the plans. This work also consists of the following:

(a) Designing and furnishing textured form liners;

(b) Installing form liners;

(c) Applying a surface finish (color/stain application) that duplicates the unique coloring and mottled appearance of stone masonry; and

(d) Preparing a simulated stone masonry test wall and demonstrating the surface finish before beginning production work.

Material

613.02 Conform to the following Subsections:

Neat hydraulic cement grout	725.13(a)(2)
Penetrating stain	719.08
Preformed expansion joint filler	712.01(b)

Construction Requirements

613.03 Form Liner Fabrication. Take an impression of the stone shape, texture, and mortar joints from a designated location. Design form liners from the impressions according to the stone pattern shown in the plans. Submit detailed drawings of the form liner for approval according to Subsection 104.03.

613.04 Test Wall. Before production work on the simulated stone masonry, construct a 36-inch (900-millimeter) high, by 24-inch (600-millimeter) wide, by 10-foot (3-meter) long test wall according to Section 552 and these specifications.

Cast the test wall on site, using the same forming methods, procedures, form liner, texture configuration, expansion joint, concrete mixture, and color/stain application proposed for the production work. Demonstrate the quality and consistency of joint treatment, end treatment, top embossing methods, back treatment, and color/stain application on the test wall. If a test wall is unacceptable, construct a new test wall.

Begin production structural concrete work only after the test wall is approved. Begin production color/stain application only after the color/stain application on the test wall is approved. Dispose of the test wall after use.

613.05 Form Liner Installation. Furnish a form liner that attaches easily to the forming system. Install the form liner so it does not compress more than ¼ inch (6 millimeters) during the concrete pour.

Attach the form liners to the form. Attach adjacent form liners to each other with less than a ⅛-inch (3-millimeter) seam. Do not repeat the form liner pattern between expansion joints or within 20-foot (6-meter) intervals, whichever is greater.

Form expansion joints at the intervals shown in the plans. Blend the butt joints into the pattern and the final concrete surface.

Coordinate the forms with wall ties. Place form tie holes in the high point of rustication or in the mortar joint.

Clean off build-up before reusing form liners. Visually inspect each liner for blemishes and tears. Repair the liner before installation.

613.06 Top Surface. Emboss the plastic concrete in the exposed top surface by stamping, tooling, troweling, hand shaping, or a combination thereof, to simulate the stone masonry texture and mortared joints. Match the side pattern of the formed mortared joints. Immediately after the free surface water evaporates and the finish embossing is complete, cure the concrete for 7 days according to Subsection 552.15(b). Do not use liquid membrane curing compounds.

613.07 Form Liner Removal. Within 24 hours after placing concrete, remove or break free the form liners without causing concrete surface deterioration or weakness in the substratum. Remove form tie material to a depth of at least 1 inch (25 millimeters) below the concrete face without spalling and damaging the concrete.

Cure the concrete for 7 days according to Subsection 552.15(b). Do not use liquid membrane curing compounds.

613.08 Preparation of Concrete Surface. Finish exposed formed concrete surfaces according to Subsection 552.16(b). Finish so that vertical seams, horizontal seams, and butt joint marks are not visible. Minimize grinding and chipping to avoid exposing aggregate.

Provide a completed surface free of blemishes, discolorations, surface voids, and conspicuous form marks. Make the finished texture and patterns continuous without visual disruption.

613.09 Color/Stain Application. Age concrete, including patches, at least 30 days. Clean the surface of latency, dirt, dust, grease, and foreign material by approved methods.

Remove efflorescence with a pressure water wash. Use a fan nozzle held perpendicular to the surface at a distance between 24 and 36 inches (600 and 900 millimeters). Use a minimum 3,000 pounds per square inch (20-megapascals) pressure at a rate of 3 to 4 gallons (12 to 16 liters) per minute. Do not sand blast surfaces that receive color/stain.

Correct surface irregularities created by the surface cleaning.

Maintain the concrete temperature between 40 and 85 °F (4 and 30 °C) when applying color/stain and for 48 hours after applying color/stain.

Color/stain exposed concrete surfaces. Use a color/stain application suitable to obtain the appearance of the native stone masonry. Use at least 3 colors/stains.

When required at boundaries between two color tones or between surfaces receiving color at different times, take care and provide protection to avoid over-spray and color overlap.

Apply grout of a natural cement color to each form joint. Use sufficient grout so the over-spray of the color/stain is not visible. Give the form pattern grout joint the appearance of mortared joints in completed masonry.

Recoat areas inconsistent with the approved test wall.

Treat expansion joints with caulk/grout to blend with the appearance of the adjacent stone or mortar joint.

613.10 Acceptance. Material for simulated stone masonry surface treatment will be evaluated under Subsections 106.02 and 106.03.

Installation of form liners will be evaluated under Subsections 106.02 and 106.04.

Application of color/stain to exposed concrete surfaces will be evaluated under Subsection 106.02.

Construction of the simulated stone masonry test wall will be evaluated under Subsection 106.02.

Construction of simulated stone masonry surfaces will be evaluated under Subsections 106.02 and 106.04.

Measurement

613.11 Measure the Section 613 pay items listed in the bid schedule according to Subsection 109.02.

Payment

613.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 613 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 614. — LEAN CONCRETE BACKFILL

Description

614.01 This work consists of constructing lean concrete backfill or flowable fill.

Material

614.02 Conform to the following Subsections:

Aggregate for lean concrete backfill	703.15
Fly ash	725.04(a)
Hydraulic cement	701.01
Water	725.01(a)

Construction Requirements

614.03 Composition of Mix. Design a well-graded, flowable, self-leveling mix. Verify the mix design with trial batches prepared from the same sources proposed for the mix. Submit the following for approval at least 21 days before production:

(a) Type and sources of aggregates;

(b) Type and source of cement;

(c) Mix proportions;

(d) Type of cement and fly ash (if used in the mix);

(e) Commercial certifications for cement, fly ash, admixtures, and aggregate;

(f) Target values for water/cementitious material ratio and slump; and

(g) Compressive strength at 7 days of 75 to 250 pounds per square inch (0.52 to 1.8 megapascals) maximum.

614.04 General. Perform the work described under Section 209.

Do not place lean concrete backfill in contact with aluminum or aluminum-coated structures.

Do not use lean concrete backfill above the top of subgrade.

614.05 Mixing and Placing Lean Concrete Backfill. Mix lean concrete backfill by pugmill, rotary drum, or other approved mixer to obtain a uniform mix.

Place lean concrete backfill in a uniform manner that prevents voids or segregation in the backfill.

When backfilling around culverts and other structures, place lean concrete backfill in a manner that does not float or shift the structure. Bring the backfill up evenly on all sides of the structure.

When placing lean concrete backfill at or below an atmospheric temperature of 35 °F (2 °C), perform the work under Subsection 552.10(a).

Wait at least 4 hours before backfilling over lean concrete backfill.

614.06 Acceptance. Lean concrete backfill will be evaluated under Subsections 106.02 and 106.03.

Backfilling with lean concrete will be evaluated under Subsection 106.02.

Measurement

614.07 Measure the Section 614 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring lean concrete backfill by the cubic yard (cubic meter), measure in the hauling vehicle.

Payment

614.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 614 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 615. — SIDEWALKS, PADS, AND PAVED MEDIANS

Description

615.01 This work consists of constructing sidewalks, pads, and paved medians.

Sidewalks, pads, and paved medians are designated as concrete, asphalt, concrete paving unit, or paving brick.

Material

615.02 Conform to the following Sections and Subsections:

Asphalt concrete	403
Bedding material	704.02
Elastomeric joint sealant	712.01(a)(4)
Minor concrete	601
Paving brick	725.08
Precast concrete units and accessories	725.09(c) or (f)
Preformed expansion joint filler for concrete	712.01(b)(1)
Reinforcing steel	709.01

Construction Requirements

615.03 General. Excavate and backfill according to Section 209. Place bedding material in layers not exceeding 4 inches (100 millimeters) in compacted thickness. Compact each layer with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

615.04 Concrete Sidewalks, Pads, and Medians. Perform the work according to Section 601. Use forms extending the full depth of concrete.

(a) Joints. Construct joints perpendicular to the outside slab edges and other joints. Match the joints in adjacent curb or pavement. Tool and remove free mortar and concrete from joints.

(1) Expansion joints. Construct at intervals not exceeding 20 feet (6 meters). Use ¾-inch (19-millimeter) thick preformed expansion joint filler for the full depth of the joints. If joints are sealed, use elastomeric joint sealant.

(2) Contraction joints. Construct at intervals not exceeding 10 feet (3 meters). Form joints with a jointing tool or saw joints to a depth of ¼ to ⅓ the thickness of the concrete and about ⅛ inch (3 millimeters) wide.

(3) Construction joints. Form construction joints around appurtenances (such as manholes, utility poles, buildings, and bridges). Use ½-inch (13-millimeter) thick preformed expansion joint filler to full depth of the joints. If joints are sealed, use elastomeric joint sealant.

(b) Finishes. Provide a sidewalk finish. Edge slab edges and joints with a ¼-inch (6-millimeter) radius edging tool.

(1) Sidewalk finish. See Subsection 552.14(c)(2).

(2) Exposed aggregate finish. See Subsection 552.14(c)(4).

Cure the concrete according to Subsection 552.15. Protect the work from pedestrian traffic for 72 hours.

615.05 Asphalt Concrete Sidewalks, Pads, and Medians. Perform the work according to Section 403.

615.06 Concrete Paving Unit and Paving Brick Sidewalks, Drive Pads, and Medians. Lay units or bricks in successive courses on a prepared surface. Lay each course to grade. Relay courses that deviate from a straight line by more than 2 inches in 30 feet (55 millimeters in 9 meters).

Sweep and inspect the surface before the bed sets. Remove and replace imperfect units or bricks.

Chock the joints flush with a dry mixture of 4 parts sand and 1 part cement by mass and carefully water the surface to saturate the joint filler.

615.07 Acceptance. See Table 615-1 for sampling, testing, and acceptance requirements.

Paving brick, concrete paving units, and joint filler and sealant will be evaluated under Subsections 106.02 and 106.03.

Bedding material will be evaluated under Subsections 106.02 and 106.04.

Construction of sidewalks, pads, and medians will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Asphalt concrete will be evaluated under Section 403.

Minor concrete will be evaluated under Section 601.

Measurement

615.08 Measure the Section 615 pay items listed in the bid schedule according to Subsection 109.02.

Payment

615.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 615 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 615-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Bedding material (704.02)	Measured and tested for conformance (106.04 & 105)	Gradation	–	Subsection 704.02	1 per soil type and source of material	Source of material	Yes	Before using in work	Not required when using Government-provided source
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Production									
Bedding material (704.02)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3 (500 m^3)	Production output or stockpile	Yes	4 hours	–
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–

Section 616. — SLOPE PAVING

Description

616.01 This work consists of constructing concrete, masonry block, rubble, or cellular concrete block slope paving.

Reinforced geotextile is designated according to Tables 714-5 and 714-6.

Material

616.02 Conform to the following Sections and Subsections:

Bedding material	704.02
Concrete masonry units	725.07
Minor concrete	601
Mortar	712.02
Nonshrink grout	725.13(b)
Paving brick	725.08
Reinforcement geotextile	714.04
Solid concrete interlocking paving units	725.09(f)
Stone masonry (rubble)	620
Topsoil	713.01
Welded deformed steel wire fabric	709.01(j)

Construction Requirements

616.03 General. Excavate and backfill according to Section 209. Place and compact bedding material with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

616.04 Reinforcement Geotextile. When required, place reinforcement geotextile according to Subsection 207.05. Bury the ends of the reinforcement geotextile for anchorage. Pin the strips at 5-foot (1.5-meter) intervals to hold the reinforcement geotextile lap in place until slope paving is placed.

616.05 Concrete Slope Paving. Construct toe walls. Place welded deformed steel wire fabric at the center of the slab. Run the wire fabric continuously through the joints. Lap adjacent runs of wire fabric by at least 6 inches (150 millimeters).

Perform concrete work according to Section 601. Place slabs starting at the bottom of the slope. Construct horizontal joints parallel to the bottom of the slope and the vertical joints perpendicular to the horizontal joints. Construct cold joints without filler.

Finish the surface according to Subsection 552.14(c)(2). Use a ¼-inch (6-millimeter) radius edging tool on slab edges and joints.

616.06 Masonry Block or Rubble Slope Paving. Begin placing masonry block or rubble at the bottom of the slope. Place paving material on the bedding material with the flat face up and the longest dimension parallel to the bottom of the slope. Ram the masonry block or rubble into place.

Apply sufficient mortar on the exposed side to produce masonry block joints up to ½ inch (13 millimeters) wide and rubble joints up to 1 inch (25 millimeters) wide. Ram the masonry block or rubble into place, so the mortar is within ½ inch (13 millimeters) of the surface. Do not allow mortar to protrude above the surface. Clean mortar stain from the surface.

616.07 Cellular Concrete Block Slope Paving. Begin placing blocks in a trench or against a suitable anchorage at the bottom of the slope. Lay each block on the slope and bed it firmly against adjoining blocks. Use grout to fill misaligned joints or breaks at slope changes. Do not grout individual blocks to each other.

Spread topsoil loosely over the cellular block slope paving, partially filling the cell openings. When required, establish turf according to Section 625.

616.08 Acceptance. See Table 616-1 for sampling, testing, and acceptance requirements.

Cellular concrete blocks, concrete masonry blocks, mortar, and welded steel wire fabric will be evaluated under Subsections 106.02 and 106.03.

Bedding material will be evaluated under Subsections 106.02 and 106.04.

Slope paving construction will be evaluated under Subsections 106.02 and 106.04.

Reinforcement geotextile will be evaluated under Section 207.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Rubble will be evaluated under Section 620.

Topsoil will be evaluated under Section 624.

Turf establishment will be evaluated under Section 625.

Measurement

616.09 Measure the Section 616 pay items listed in the bid schedule according to Subsection 109.02.

Payment

616.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 616 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 616-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Bedding material (704.02)	Measured and tested for conformance (106.04 & 105)	Gradation	–	Subsection 704.02	1 per soil type and source of material	Source of material	Yes	Before using in work	Not required when using Government-provided source
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Production									
Bedding material (704.02)	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3 (450 m^3)	Production output or stockpile	Yes	4 hours	–
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–

Section 617. — GUARDRAIL

Description

617.01 This work consists of installing guardrail systems and modifying, removing and resetting, and raising existing guardrail systems.

(a) Guardrail systems are designated as follows:

CRG — Curved radius W-beam guardrail
G1 — Cable guardrail
G2 — W-beam (weak post)
G3 — Box beam
G4 — Blocked-out W-beam standard barrier
G9 — Blocked-out thrie beam standard barrier
MB4 — Blocked-out W-beam median barrier
SBLG — Steel-backed log rail
SBTA — Steel-backed timber (SBT) guardrail/timber posts and block-out
SBTB — SBT guardrail/timber posts and no block-out

(b) Steel guardrail types are designated as follows:

I — Zinc-coated, 1.80 ounces per square foot (550 grams per square meter)
II — Zinc-coated, 3.60 ounces per square foot (1100 grams per square meter)
III — Painted rails
IV — Corrosion resistant (weathering) steel

(c) Steel guardrail classes are designated as follows:

A — Metal thickness — 0.105 inches (2.67 millimeters) (12-guage)
B — Metal thickness — 0.135 inches (3.43 millimeters) (10-guage)

(d) Terminals consist of posts, railing, hardware, and anchorage assembly necessary to construct the type of terminal specified. Terminal types are designated as follows:

Flared — Straight or parabolic flared W beam terminal
G4-BAT — Back slope anchor terminal
G4-CRT — Cable releasing terminal
SBT-BAT — Back slope anchor terminal
SBT-FAT — Flared SBT anchor terminal
SBT-Tangent — Tangent SBT terminal
Tangent — Tangent W beam terminal

Material

617.02 Conform to the following Section and Subsections:

Guardrail blocks	710.08
Guardrail hardware	710.10
Guardrail nuts, bolts, and cables	710.09
Guardrail posts	710.07
Minor concrete	601
Rail elements	710.06

Construction Requirements

617.03 General. Furnish guardrail systems and terminals that are crashworthy. When flared or tangent terminals are required, submit drawings from the manufacturer for the terminals according to Subsection 104.03.

Place concrete according to Section 601.

Perform welding according to Subsection 555.17.

617.04 Post Installation. Treat field cuts for wood posts with two coats of preservative specified in Subsection 710.07. Do not place field cuts in contact with the ground.

Install the posts plumb and at the location, spacing, and elevation specified, or as directed by the CO.

When the pavement surface is within 36 inches (900 millimeter) of the guardrail face, install posts before placing the pavement surface. Protect posts from traffic by attaching the rail elements or by a method approved by the CO.

Posts may be installed by either drilling or driving. Ensure posts installed by drilling have sufficiently sized holes to permit thorough compaction of backfill material around the post. Backfill in compacted layers not exceeding 12 inches (300 millimeters). Replace posts damaged during driving operations.

When a post cannot be placed at its normal location due to an impenetrable object an additional blockout may be added. If the post cannot be offset, follow the post in rock detail or use the long span detail as shown in the plans or as approved by the CO. Do not change the post lengths or spacings in terminal sections.

When it is not possible to maintain a 24-inch (600-millimeter) minimum distance between the back of the guardrail post and the top of a 1V:2H or steeper slope, increase the standard post length by 12 inches (300 millimeters).

617.05 Rail Element Installation. Do not modify specified hole diameters or slot dimensions.

(a) Steel rail. Shop bend curved guardrail with a radius of 150 feet (45 meters) or less.

Install rail elements in a smooth continuous line with the laps in the direction of traffic flow. Use bolts that extend at least ¼ inch (6 millimeters), but not more than 1 inch (25 millimeters) beyond the nuts.

Paint scrapes on galvanized surfaces that expose the base metal with two coats of zinc-oxide paint.

(b) Steel-backed timber and log rail. Treat field cuts with two coats of preservative.

617.06 Terminal Sections. Do not connect the guardrail to cast-in-place anchors until the concrete has cured 7 days. Install end anchor cables without slack.

617.07 Connection to Structure. Install posts, railing, hardware, and anchorage assembly necessary to construct the type of connection to structure specified.

617.08 Guardrail Construction Exposed to Traffic. When a roadway is open to traffic during construction, complete guardrail installations within 5 days from the day the structure, pavement, shoulder, or whichever is the controlling item of work is sufficiently completed to allow guardrail installation. In areas where guardrail construction is not restricted by other construction, complete removal of existing guardrail and construct new guardrail within 48 hours of starting work.

At the end of each day, securely bolt a rounded end section to the exposed end of the guardrail.

Schedule guardrail installation so work is finished before work suspension or other extended periods of time.

617.09 Removing and Resetting Guardrail. Remove and store the existing rail elements, posts, and appurtenances. Remove and dispose of posts that are set in concrete. Replace guardrail, posts, and hardware damaged during removal, storage, or resetting. Backfill holes resulting from the removal of guardrail posts and anchors with material approved by the CO. Dispose of material not used in resetting guardrail according to Section 203.

617.10 Raising Guardrail. Remove the existing rail elements and appurtenances. Replace and reset posts as needed. Replace rail elements, posts, and hardware damaged during the removal and raising. Dispose of damaged material according to Section 203.

617.11 Acceptance. Material for guardrail will be evaluated under Subsections 106.02 and 106.03.

Construction of guardrail will be evaluated under Subsections 106.02 and 106.04.

Welding will be evaluated under Section 555.

Measurement

617.12 Measure the Section 617 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure transition sections from G9 rail to G4 rail as G9 rail.

Measure removing and resetting guardrail and raising guardrail including reset terminal sections.

Measure replacement posts (except replacement posts for posts damaged by construction operations) used in the removing and resetting, or raising guardrail.

Payment

617.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 617 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 618. — CONCRETE BARRIERS AND PRECAST GUARDWALLS

Description

618.01 This work consists of constructing and resetting concrete barrier and precast guardwall systems.

Material

618.02 Conform to the following Section and Subsections:

Backer rod	712.01(f)
Guardrail hardware	710.10
Joint sealants	712.01(a)
Precast concrete barrier	725.09(b)
Preformed expansion joint filler	712.01(b)
Reinforcing steel	709.01
Structural concrete	552

Construction Requirements

618.03 General. Excavate and backfill according to Section 209.

Construct barriers and guardwalls that are crashworthy.

Furnish concrete Class A(AE) conforming to Section 552.

618.04 Concrete Barriers. Concrete barriers may be cast-in-place, slip-formed, or precast according to Section 552. Finish the sides and top according to Subsection 552.16(a).

(a) Cast-in-place. Tool or saw cut contraction joints ¼ inch (6 millimeters) wide and 2 inches (50 millimeters) deep at 20-foot (6-meter) intervals. Saw cut after the concrete has set sufficiently, but before shrinkage cracking occurs. Decrease the depth of the saw cut at the edge adjacent to the pavement to prevent pavement damage.

Place ¾-inch (19-millimeter) preformed expansion joint filler in construction joints. Cut the joint filler to fit the cross-sectional area at structures and barrier construction joints. Tool construction joint edges. Seal joints according to Subsection 501.11.

(b) Slip-formed. Do not contact extruded concrete surface as it leaves the slip-form machine, except to remove offsets and fins by light troweling.

Make adjustments in the operation to correct conditions causing surface blemishes larger than ½ inch (13 millimeters). Do not use water on the completed barrier to correct imperfections.

(c) Precast. Precast barriers in section lengths. Prepare the barrier foundation so it does not vary over ¼ inch (6 millimeters) when a 10-foot (3-meter) straightedge is laid along the centerline of the barrier. Align the joints and connect adjacent sections.

Use cast-in-place barrier where transitions, split barriers, or gaps shorter than 10 feet (3 meters) require it. At each joint between precast and cast-in-place barrier, provide hardware in the cast-in-place section to tie its end to the abutting precast section.

618.05 Precast Concrete Guardwall.

(a) Fabrication. A full-size sample of the guardwall will be provided at a specified location. Fabricate the guardwall to match the sample's shape, color, texture, and the following:

(1) Fabricate in a facility certified by the National Precast Concrete Association (NPCA) and according to the NPCA, *Manual of Quality Control for Precast and Prestressed Concrete Plants*;

(2) Formulate the facing mixes, backing mixes, and structural concrete backup to produce concrete mix designs of similar aggregate-cement ratios to minimize differences in shrinkage factors and coefficients of thermal expansion and contraction. Formulate a concrete mixture according to Subsection 552.03 to match the approved sample;

(3) Use epoxy-coated reinforcing steel at locations where the reinforcing steel is less than 2 inches (50 millimeters) from the exposed surface;

(4) Cast the sections straight and true;

(5) Cast the facing mixes at least 1 inch (25 millimeters) thick. Ensure a good bond between facing and backup mixes; and

(6) Provide lifting devices with removable caps for each precast segment.

(b) Test section. Demonstrate the ability to match the sample by fabricating a 10-foot (3-meter) full-scale guardwall test section and delivering it to the location of the sample for comparison. If the test section is not approved, fabricate another test section according to Subsection 618.05(a). Do not construct additional guardwall before the sample is approved. Approved test sections may be used in the guardwall construction.

(c) Installation. Produce guardwall sections to match the approved test section. Repair or replace damaged sections. Prepare the foundation by compacting the bedding material with at least three passes of a vibratory roller until there is no visible evidence of further consolidation. Place the sections using backer rods and joint sealant in the section joints to match the false joints.

At 100-foot (30-meter) intervals and at low points in the guardwall, excavate outlet ditches and backfill with 6 inches (150 millimeters) of aggregate conforming to Subsection 703.12.

618.06 Terminal Sections. Where concrete barrier or precast guardwall is being constructed next to roadway lanes open to traffic; connect an approved temporary terminal section, crash cushion, or impact attenuator to the barrier or guardwall at the end of each shift.

618.07 Resetting. Reset concrete barrier, precast guardwall, and terminal sections according to Subsections 618.03 and 618.06. Store concrete barrier and precast guardwall sections in an approved location if not reset immediately.

618.08 Acceptance. Material for concrete barrier and precast guardwall (except concrete and reinforcing steel) will be evaluated under Subsections 106.02 and 106.03.

Concrete barrier and precast guardwall appearance will be evaluated under Subsection 106.02.

Construction of concrete barriers and precast guardwalls will be evaluated under Subsections 106.02 and 106.04.

Concrete will be evaluated under Section 552.

Reinforcing steel will be evaluated under Section 554.

Measurement

618.09 Measure the Section 618 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure concrete barrier and precast guardwall excluding terminal sections.

Measure reset concrete barrier and precast guardwall in their relocated position including terminal sections.

Payment

618.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 618 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 619. — FENCES, GATES, CATTLE GUARDS AND BOLLARD POSTS

Description

619.01 This work consists of constructing fences, gates, cattle guards, and bollard posts and removing and resetting fence.

Material

619.02 Conform to the following Section and Subsections:

Barbed wire	710.01
Chain link fence	710.03
Fence gates	710.05
Fence posts and bollards	710.04
Minor concrete	601
Neat hydraulic cement grout	725.13(a)(2)
Precast concrete units and accessories	725.09(g)
Reinforcing steel	709.01
Temporary plastic fence	710.11
Woven wire	710.02

Construction Requirements

619.03 Fences and Gates.

(a) General. Clear along the fence line. Remove and dispose of trees, brush, logs, upturned stumps, roots of downed trees, rubbish, and debris according to Subsection 201.06. Clear a 10-foot (3-meter) width for chain link fence and a 36-inch (900-millimeter) width for wire fence.

Grubbing is not required, except where short and abrupt changes in the ground contour require removal of stumps to properly grade the fence line. Remove or cut stumps according to Subsection 201.04(b).

Perform clearing and leveling with minimum disturbance to the terrain outside the fence line.

Schedule the fence installation, provide temporary fence, or other adequate means to prevent livestock from entering the project right-of-way, easements, or adjoining properties.

At bridges, cattle underpasses, and culverts, connect new fence to structure to permit free passage of livestock under or through the structure.

(b) Chain link fence and gates.

(1) Posts. Space posts at not more than 10-foot (3-meter) intervals. Measure the post spacing interval horizontally. Set posts vertically.

Set posts in concrete according to Section 601.

Where solid rock is encountered without overburden, drill line post holes at least 14 inches (350 millimeters) deep. Drill end, corner, gate, and pull posts at least 20 inches (500 millimeters) deep in the solid rock. Make the hole width or diameter at least 1 inch (25 millimeters) greater than the post width or diameter. Cut the post to the required length before installation or drill the hole deep enough to set the post at the required height. Set and plumb the post and fill the hole with grout. Thoroughly work the neat hydraulic cement grout into the hole to eliminate voids. Crown the grout to drain water away from the post.

Where solid rock is covered with soil or loose rock overburden, set posts to the plan depth or to the minimum depth into the solid rock as specified above, whichever is less. When solid rock is encountered before the plan depth, grout the portion of the post in solid rock and backfill the post hole from the solid rock to the top of the ground with concrete.

Provide end, gate, corner, and pull posts with adjacent brace posts as shown in the plans. A change in the fence alignment of 20 degrees or more is considered a corner.

(2) Top rail. Install top rails through the loop caps of the line posts, forming a continuous brace from end-to-end of each stretch of fence. Join lengths of top rail with sleeve-type couplings. Securely fasten top rails to terminal posts by pressed steel fittings or other appropriate means.

(3) Tension wire. Attach tension wire to end, gate, corner, or pull posts by bands and clamps. Either thread the top tension wire through the line post loop caps or hold in open slots in a manner to limit vertical movement. Tie or attach the bottom tension wire to the bottom of the line posts by ties or clamps in a manner that prevents vertical movement. Apply sufficient tension to avoid excess sag between posts. On the top tension wire, provide one turnbuckle or ratchet take-up in each run of fence.

(4) Fence fabric. For fences placed on the right-of-way, place fence fabric on the post face away from the highway. On curved alignment, place the fence fabric on the post face on the outside of the curve. For residential fences and fences off the right-of-way, place fence fabric on the post face designated by the CO.

Place the fabric approximately 1 inch (25 millimeters) above the ground and on a straight line between posts. Excavate high points of the ground to maintain grade. Do not fill in depressions without prior approval.

Stretch the fabric taut and securely fasten the fabric to the posts. Do not stretch using a motor vehicle. Use stretcher bars and fabric bands to fasten to end, gate, corner, and pull posts or weave the fabric into the fastening loops of roll-formed posts.

Fasten fabric to line posts using wire ties, metal bands, or other approved method. Fasten the top and bottom edge of the fabric with tie wires or hog rings to the top rail or tension wires as applicable.

Join rolls of fabric by weaving a single strand into the ends of the rolls to form a continuous mesh.

(5) Gates. Fasten fabric to the end bars of the gate frame by stretcher bars and fabric bands. Fasten fabric to the top and bottom bars of the gate frame by tie wires similar to the method specified for fence fabric or by other approved standard methods.

Thoroughly clean welded connections on gate frames where the smelter coating has been burned with a wire brush. Remove traces of the welding flux and loose or cracked smelter. Paint the cleaned areas with two coats of zinc-oxide paint.

Provide a concrete footing for the drop-bar locking device on double metal gates. Make a hole to receive the locking bar to the depth specified by the manufacturer of the locking device.

Hinge each single gate to prevent removal of the gate without tools. Set the gate in an approximately horizontal plane. Set the gate so it swings freely inward and outward and fastens securely in its latch holder, or in the case of double gates, in its latch holder and gate stops. Set double gates on their respective hinge pintles to provide a common horizontal plane in which each single gate swings. Set gates to swing open at least 90 degrees in each direction.

(c) Wire fences and gates.

(1) Posts. Excavate holes for posts, footings, and anchors as shown. Space posts at intervals shown for the type of fence being installed. Measure post spacing interval parallel to the existing ground slope. Set posts in a vertical position. Backfill post holes in 6-inch (150-millimeter) lifts. Tamp and compact each lift.

Wood posts may be driven in place if the method of driving does not damage the post. Metal posts may be driven. Set metal corner, gate, end, and pull posts in concrete.

Where solid rock is encountered without overburden, drill line post holes at least 14 inches (350 millimeters) deep and end, corner, gate, and pull posts at least 20 inches (500 millimeters) deep in the solid rock. Make the hole width or diameter at least 1 inch (25 millimeters) greater than the post width or diameter. Cut the post to the required length before installation or drill the hole deep enough to set the post at the required height. Set and plumb the post and fill the hole with grout. Thoroughly work the grout into the hole to eliminate voids. Crown the grout to drain water away from the post. Metal posts set in this manner do not require anchor plates and concrete footings.

Where solid rock is covered with soil or loose rock overburden, set posts to the plan depth or to the minimum depth into the solid rock as specified above, whichever is less. When the depth of overburden is greater than 12 inches (300 millimeters), use an anchor plate on steel line posts and backfill steel end, corner, gate, and pull posts with concrete from the solid rock to top of the ground. When the depth of overburden is 12 inches (300 millimeters) or less, anchor plates and concrete backfill are not required. Grout the portion of the post in solid rock.

Install corner posts at changes in alignment of 30 degrees or more. Where new fence joins an existing fence, set end or corner posts, as necessary, and attach in a manner satisfactory to the CO.

(2) Braces. Limit fence runs to no more than 650 feet (200 meters) between adjacent corner braces, gate braces, end braces, or line braces. Install line braces at uniform intervals so the distance between any two braces is 650 feet (200 meters) or less. Construct braces before placing the fence fabric and wires on posts.

(a) Metal braces. Provide corner posts and pull posts with two braces, one each direction from the post in the main fence line. Provide end posts and gate posts with one brace in the line of the fence. Attach metal braces to the metal end, corner, pull, and gate posts and set in concrete as shown in the plans.

(b) Wood braces. Tap the posts to receive the braces. Anchor the brace to the post with three 16d nails or a ⅜- by 4-inch (10- by 100-millimeter) dowel. Install brace wires as shown and twist together until the entire assembly is taut and firm. Lightly notch the posts to position the brace wire. Drive three staples at each notch to secure wire.

(3) Barbed wire and woven wire. Place barbed wire and woven wire on the side of the post facing away from the highway. On curved alignment, place the barbed wire and the woven wire on the post face on the outside of the curve. Tightly stretch and fasten barbed wire and woven wire to the posts.

Apply tension according to the manufacturer's recommendations using a mechanical stretcher or other device designed for such use. Evenly distribute the pull over the longitudinal wires in the woven wire so not more than 50 percent of the original depth of the tension curves is removed. Do not use a motor vehicle to stretch the wire.

Splicing of barbed wire and woven wire between posts is permitted provided not more than two splices, spaced at least 50 feet (15 meters) apart, occur in a run of fence. Use wrap or telephone type splices for the longitudinal woven wire and barbed wire with each end wrapped around the other wire for not less than six complete turns.

(4) Fastening barbed wire and woven wire. End the woven wire and barbed wire at each end, corner, gate, and pull post. Wrap each line of barbed wire and each longitudinal wire of the woven wire around the post and then itself with at least four turns. Where wood posts are used, staple the wires tightly to the posts.

At line posts, fasten the woven wire to the post at top and bottom and at intermediate points not exceeding 12 inches (300 millimeters) apart. Fasten each strand of barbed wire to each line post. Use wire ties or clamps to fasten the wires to metal posts. Securely splice tie wires to the fence on both sides of the post so there are two loops behind the post and one loop in front. On wood line posts, drive U-shaped staples diagonally across the wood grain so that both points do not enter between the same grain. In depressions where wire uplift occurs, drive staples with points slightly upward. On level ground and over knolls, slope the points slightly downward. Drive the staples just short of actual contact with the wires to permit free longitudinal movement of those lines and to prevent damage to the protective coating.

At grade depressions, alignment angles, and other locations where stresses tending to pull posts from the ground or out of alignment are created, snub or guy the wire fence. Attach the guy wire to each strand of barbed wire and to the top and bottom wires of woven wire in a manner to maintain the entire fence in its normal shape. Attach the guy wire to a deadman anchor buried not less than 24 inches (600 millimeters) in the ground or to an approved anchor at a point that best serves to resist the pull of the wire fence. If necessary to guy the fence in solid rock, grout the guy wire in a hole 2 inches (50 millimeters) in diameter and 10 inches (250 millimeters) deep. Deadman may also be fastened to posts. Place the deadman anchors at locations as directed.

Where required, install vertical cinch stays as shown. Twist the wire to permit weaving into the horizontal fence wires to provide rigid spacing. Weave barbed wires and the top, middle, and bottom wire of the woven wire as applicable, into the cinch stay.

Where existing fence intersects the new fence, cut the existing fence material or, splice in kind, new material as necessary, and fasten each longitudinal wire of the woven wire and each strand of the barbed wire to a new end post in line with or immediately adjacent to the new fence line.

(5) Gates.

(a) Wire gates. Construct wire gates of the same material as the fence and as shown. Provide a taut and well-aligned closure of the opening, capable of being readily opened and closed by hand.

(b) Metal gates. Install metal gates and fittings to gate posts previously set. Firmly attach the fittings to the posts and gates. Hinge each single gate to prevent removal of the gate without tools. Set the gate in a horizontal plane. Set the gate so it swings freely inward and outward and fastens securely in its latch holder, or in the case of double gates, in its latch holder and gate stops. Set double gates and their respective pintles to provide a common horizontal plane in which each single gate swings. Set gates to swing open at least 90 degrees in each direction.

For double gates, provide a drop-bar locking device with a concrete footing 12 inches (300 millimeters) in diameter and 12 inches (300 millimeters) deep. Crown the top of the footing and make a hole to receive the locking bar. Make the diameter and depth of the hole in the footing as specified by the manufacturer of the locking device.

(c) Wood gates. Install wood gates similar to metal gates and as shown in the plans.

619.04 Grounding Fences. Where an electric line crosses the fence line, ground the fence. Drive an 8-foot (2.4-meter) long, ½-inch (13-millimeter) minimum diameter galvanized or copper coated steel rod into the ground under the fence directly below the point of crossing. Drive the rod vertically until the top is 6 inches (150 millimeters) below the ground surface. Connect the grounding rod to each fence element with a ¼-inch (6-millimeter) diameter solid copper conductor or equivalent. Either braze the connections or fasten with noncorrosive clamps.

Where an electric line runs parallel or nearly parallel to and above the fence, ground the fence at each end or gate post or at intervals not exceeding 1,600 feet (500 meters).

Where vertical penetration of the grounding rod cannot be accomplished, use an equivalent horizontal grounding system.

619.05 Remove and Reset Fence. Remove existing fence and reset to approximately the same condition as the original fence. Salvage material in the existing fence and incorporate the material into the reset fence. When posts are set in concrete, remove concrete from old post and reset in new concrete. Replace fence material damaged beyond reuse. Firmly reset posts on new alignment. Space posts and attach the horizontal members or wires to posts the same as the original fence. Furnish and use new material to fasten members or wires to posts.

619.06 Temporary Fence. When necessary, construct temporary fence to keep traffic (such as pedestrian, livestock, and vehicular) off the project. Maintain the temporary fence during construction of the project or until the fence is directed to be removed. Dispose of temporary fence according to Subsection 203.05(a).

619.07 Cattle Guards.

(a) Excavating and backfilling. Perform the work described under Section 209. Excavate foundation to depth with sufficient space for proper installation of formwork.

When the cattle guard is to be installed on new embankment, complete and compact the embankment according to Section 204 before excavating for footing.

(b) Concrete foundation. Concrete cattle guard foundations may be cast-in-place or precast. Construct cast-in-place concrete foundations according to Section 601. Set cattle guard units in the foundation concrete before it hardens.

Finish stringer bearings to allow full bearing under each stringer. Firmly seat cattle guard on the concrete to prevent rocking.

(c) Cattle guard. Fabricate cattle guard according to Section 555. Assemble and place guards as shown in the plans. Securely fasten the cattle guard to the foundation. Fasten the metal wings as shown in the plans. Connect fences and gates as shown in the plans. Weld according to AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)*.

Standard manufactured cattle guards may be used if approved. Furnish cattle guards with HS-20 (M-18) loading rating according to AASHTO, *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*. Provide suitable cleanouts. Submit drawings according to Subsection 104.03.

(d) Painting. Paint according to Section 563. Apply one shop coat to metal parts. Apply two additional coats in either the shop or in the field.

619.08 Bollards. Drill holes for bollards. Set posts plumb, backfill with approved material, and compact.

619.09 Acceptance. Material for fences, gates, cattle guards, and bollards will be evaluated under Subsections 106.02 and 106.03.

Construction and erection of fences, gates, cattle guards, and bollards will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill for cattle guards will be evaluated under Section 209.

Structural steel work for cattle guards will be evaluated under Section 555.

Painting of cattle guards will be evaluated under Section 563.

Concrete work for cattle guards will be evaluated under Section 601.

Measurement

619.10 Measure the Section 619 pay items listed in the bid schedule according to Subsection 109.02.

Payment

619.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 619 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 620. — STONE MASONRY

Description

620.01 This work consists of constructing or rehabilitating stone masonry structures and the stone masonry portions of composite structures.

Masonry class is designated as follows:

(a) Dimensioned masonry. Stones are cut in two or more dimensions and laid in a broken-course pattern in mortar;

(b) Class A masonry. Stones are shaped, dressed to within ¼ inch (6 millimeters) of true line, and laid in mortar;

(c) Class B masonry. Stones are shaped, dressed to within ¾ inch (19 millimeters) of true line, and laid in mortar; and

(d) Rubble masonry. Stones vary in size and shape, are roughly dressed, and laid in random courses in mortar.

Material

620.02 Conform to the following Section and Subsections:

Minor concrete	601
Mortar	712.02
Neat hydraulic cement grout	725.13(a)(2)
Preformed expansion joint fillers	712.01(b)
Reinforcing steel	709.01
Rock for masonry structures	705.03

Construction Requirements

620.03 General. Submit stone samples representing the range of colors and sizes to be used 14 days before beginning work.

Keep an adequate inventory of stone on the site to provide a variety of stones. Mix new stone with existing stone to produce a uniform pattern and color.

Perform excavation and embankment according to Section 209.

620.04 Dressing Rock. Remove thin or weak portions of rock. Dress face rock bed and joint lines to a maximum variation from true line as follows:

- Dimensioned masonry — Reasonably true
- Class A masonry — ¼ in (6 mm)
- Class B masonry — ¾ in (19 mm)
- Rubble masonry — 1½ in (38 mm)

(a) Bed surfaces. Dress face rock bed surfaces normal to the face to a depth of 3 inches (75 millimeters). Beyond that point, do not exceed 1 inch (25 millimeters) in 12 inches (300 millimeters) the departure from normal for dimensioned masonry or 2 inches (50 millimeters) in 12 inches (300 millimeters) for other classes.

(b) Joint surfaces. For dimensioned masonry, dress face rock joint surfaces normal to the bed surface. For other classes of masonry, dress face rock joint surfaces to form an angle with the bed surface of not less than 45 degrees.

Dress face rock joint surfaces normal to the face to a depth of 2 inches (50 millimeters). Beyond that point, do not exceed 1 inch in 12 inches (25 millimeters in 300 millimeters) departure from normal.

Do not round corners at the meeting of the bed and joint lines in excess of the following radii:

(1) Dimensioned masonry — No rounding

(2) Class A masonry — No rounding

(3) Class B masonry — 1 inch (25 millimeters)

(4) Rubble masonry — 1½ inches (38 millimeters)

(c) Arch ring rock joint surfaces. Dress ring rock joint surfaces radial to the arch or normal to the front face to a depth of 3 inches (75 millimeters). Beyond that point, the departure from the radial or normal may not exceed ¾ inch in 12 inches (19 millimeters in 300 millimeters).

Dress the back surface adjacent to the arch barrel concrete parallel to the front face and normal to the intrados to a depth of 6 inches (150 millimeters). When concrete is placed after the masonry is constructed, vary adjacent ring stones at least 6 inches (150 millimeters) in depth.

(d) Finish for exposed faces. Remove drill or quarry marks from exposed faces. Pitch face stones to the line along beds and joints. Finish the exposed faces as specified in the contract. The following abbreviations are used to represent the type of surface or dressing specified:

(1) Fine pointed (F.P.). Make point depressions approximately ⅜ inch (10 millimeters) apart. Limit surface variations to ⅛ inch (3 millimeters) or less from the pitch line.

(2) Medium pointed (M.P.). Make point depressions approximately ⅝ inch (15 millimeters) apart. Limit surface variations to ¼ inch (6 millimeters) or less from the pitch line.

(3) Coarse pointed (C.P.). Make point depressions approximately 1⅛ inches (29 millimeters) apart. Limit surface variations to ⅜ inch (10 millimeters) or less from the pitch line.

(4) Split or seam face (S.). Provide a smooth appearance, without tool marks, with no depressions below the pitch line, and no projection exceeding ¾ inch (19 millimeters) beyond the pitch line.

(5) Rock faced (R.F.). Provide an irregular projecting surface without tool marks, concave surfaces below the pitch line, and projections beyond the specified pitch line. For example, the specification "1.50 R.F." ("38 R.F") means no projections 1½ inches (38 millimeters) beyond the pitch line. Where a "*variable rock face*" is specified, uniformly distribute stones of the same height of projection.

620.05 Placing Stone. Do not place stone masonry when the ambient temperature is below 32 °F (0 °C).

Clean stones and moisten before placing. Use hand tools to clean the exposed faces of the stones of mortar when removing and resetting stone masonry. Clean and moisten the bed. Clean the bearing surface and moisten before spreading the mortar bed on footings.

Level the cross beds for vertical walls. Lay beds for battered walls from level to normal to the batter line of the face of the wall.

Place stone to provide a consistent pattern and color. Lay stones with the longest face horizontal and the exposed face parallel to the masonry face.

Construct masonry joints to the thicknesses shown in Table 620-1 for face stones. Construct ring stone joints on the faces and soffits between ¼ inch (6 millimeters) and 1½ inches (38 millimeters) thick, but make the bed of each course of a uniform thickness throughout. Construct head joints vertically in dimensioned masonry. Construct head joints in other masonry classes at angles with the vertical from 0 to 45 degrees.

Maintain completed masonry at a temperature above 40 °F (4 °C) for 24 hours after construction.

Remove stones loosened after the mortar has taken initial set, clean off the mortar, and relay the stone with fresh mortar.

Table 620-1
Masonry Joint Thicknesses

Class	Bed Joint	Head Joints
Dimensioned	⅜ – 1 inches (10 – 25 millimeters)	¾ – 1 inches (19 – 25 millimeters)
Class A	½ – 2 inches (13 – 50 millimeters)	½ – 1½ inches (13 – 38 millimeters)
Class B	½ – 2 inches (13 – 50 millimeters)	½ – 2 inches (13 – 50 millimeters)
Rubble	½ – 2½ inches (13 – 64 millimeters)	½ – 2½ inches (13 – 64 millimeters)

620.06 Pointing.

(a) Pointing new joints. Crown the joint mortar slightly on top surfaces to provide drainage.

Where raked joints are required, squarely rake mortar in exposed face joints and beds to the required depth. Slightly rake the mortar where weather joints are required. Do not leave the mortar flush with the stone faces.

Clean stone faces of mortar stains while the mortar is fresh. After the mortar sets, clean stone faces again using wire brushes and acid. Protect masonry during hot or dry weather by keeping it moist for at least 3 days after the work is completed.

(b) Repointing joints. Remove loose mortar from joints using a small mason's chisel, small pneumatically-power chisel, or other raking tool approved by the CO. Do not use power saws or grinders. Demonstrate proficiency if power equipment is used before removing mortar from the structure. Remove mortar to a depth of two and one-half times the width of the joint. Remove dirt or vegetation with a wire brush or other approved tools. Clean joint of loose fragments and dust with pressurized air or water.

Construct a 36-inch (900-millimeter) test section of joint along the structure for approval before continuing with work. Approved test section may be incorporated into the work. Moisten adjacent stone before filling the joint. Do not place mortar to a depth greater than two and one-half times the joint width. Place mortar in layers of approximately ¼ inch (6 millimeters) for joints deeper than ⅛ inch (3 millimeters). Add successive layers once mortar has reached thumb-print hardness. Tool the final layer to match the approved joint appearance.

Clean excess mortar and stain from stone masonry using a bristle brush after the mortar has dried, but before the initial set. Do not use chemicals for cleaning. Protect masonry during hot or dry weather by keeping it moist for at least 3 days after the work is completed.

620.07 Constructing Walls. Construct an L-shaped test section of wall at least 5 feet (1.5 meters) high and 8 feet (2.4 meters) long; showing examples of face wall, top wall, method of turning corners, and method of forming joints. Do not construct masonry other than the foundation masonry before the test section is approved.

Set face stones to produce the effect demonstrated in the approved test section. Do not extend bed joints in an unbroken line through more than five stones and head joints through more than two stones. Bond each face stone with contiguous face stones at least 6 inches (150 millimeters) longitudinally and 2 inches (50 millimeters) vertically. Do not allow the corners of four stones to be adjacent to each other.

Do not bunch small stones or stones of the same size, color, or texture. Construct walls using stones decrease in size from the bottom to the top. Use large, stones in corners.

(a) Headers. Distribute headers uniformly throughout the walls of structures to form at least 20 percent of the faces.

(b) Backing. Construct the backing out of large stones. Bond the individual stones composing the backing and heart with the stones in the face wall and with each other. Fill openings and interstices in the backing with mortar or with spalls surrounded by mortar.

(c) Coping. Finish with coping when shown in the plans. When copings are not required, finish the top of the wall with stones wide enough to cover the top of the wall from 1.5 to 5 feet (0.5 to 1.5 meters) in length, and of random heights, with a minimum height of 6 inches (150 millimeters). Lay stones in a manner that the cap course is an integral part of the wall. Pitch the top of the capstones to align in both vertical and horizontal planes.

(d) Parapet walls. Use stones squared and pitched to line and with heads dressed in the ends of parapet walls and in exposed angles and corners. Interlock spreaders with as many headers as possible. Extend headers through the entire wall thickness. Interlock both the headers and stretchers in the two faces of the wall. Use headers and stretchers to comprise a majority of the wall volume. Fill openings and interstices with mortar or with spalls surrounded by mortar.

(e) Weep holes. Place weep holes at the lowest points where free outlets can be obtained. Space holes no more than 10 feet (3 meters) apart.

620.08 Facing for Concrete.

(a) Stone placed before concrete. Make the back of the masonry uneven. Pack voids in the back of the masonry with grout.

Use No. 4 (13M) reinforcing steel bent into an elongated letter "*S*" to anchor the stone. Embed each anchor in a mortar bed to within 2 inches (50 millimeters) from the face of the stones. Project the other end about 10 inches (250 millimeters) into the concrete backing. Space the anchors 18 inches (450 millimeter) apart both horizontally and vertically.

Clean the back masonry surface of dirt, loose material, and mortar drippings after the mortar has attained sufficient strength. Wash surfaces with pressurized water before placing concrete.

(b) Concrete placed before stone. Set galvanized metal anchor slots flush with the projected face of concrete. Set the slots vertically at maximum horizontal spacings of 24 inches (600 millimeters). Use foam filled slots to prevent filling with concrete.

Fit the metal anchors in the slots at a maximum vertical spacing of 24 inches (600 millimeters). Extend the anchors to within 2 inches (50 millimeters) of the face of the stones.

If the shape of the concrete face is unsuitable for the use of metal slots, use 9 gage (3.8-millimeter) galvanized iron wire ties at a rate of six ties for each square yard (seven ties for each square meter) of exposed surface.

Keep the concrete face continuously wet for 2 hours preceding the placing of the stone and fill interstices with mortar or with spalls surrounded by mortar.

620.09 Constructing Arches. Submit drawings for falsework according to Section 562. Stratify arch ring stones parallel to the radial joint and stratify other stones parallel to the beds.

Lay out a full-size template of the arch ring showing face dimensions of each ring stone and thickness of joints. Do not shape or dress ring stones until falsework drawings have been approved. Do not place ring stones until all ring stones have been shaped and dressed.

Construct arch centering according to the drawings. Provide suitable wedges for adjusting the elevation of the forms.

Set arch ring stones and hold in place with wedges until the joints are packed with mortar. If required, support centering with jacks to prevent settlement during masonry placement. Lower the centering gradually and symmetrically to avoid overstresses in the arch. Ensure the arch is self-supporting before installing coping or other features.

Strike the centers of filled spandrel arches before constructing the spandrel walls to avoid jamming of the expansion joints. Place the backfill so the ring is uniformly and symmetrically loaded.

620.10 Guardwall. Use rubble masonry. Construct cast-in-place or precast concrete corewalls according to Section 601. Use concrete with a minimum 28-day compressive strength of 3,500 pounds per square inch (25 megapascals).

Construct a 25-foot (8-meter) test section of guardwall. Do not construct additional guardwall until the test section is approved.

Construct the guardwall true and uniform along its length with no stone projecting more than 1½ inches (38 millimeters) beyond the face of the guardwall. Construct masonry beds and joints for face stones to the thicknesses shown in Table 620-1. Rake the joints and beds to a depth of 2 inches (50 millimeters) on the front and top sides and to a depth of 1½ inches (38 millimeters) on the back.

Use a one-piece capstone for the full width of the guardwall for at least 25 percent of the total length. Use a two-piece capstone with the joint within 4 inches (100 millimeters) of the guardwall center for the remaining length.

Place stones (including the capstones) randomly to avoid a pattern. Lay stones to reflect the width of the expansion joints. Do not leave a gap or a mortar edge at the expansion joint. Use various size stones to coin or key the corners of the guardwall.

620.11 Acceptance. Rock for masonry structures will be evaluated under Subsections 106.02 and 106.04.

Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar placement will be evaluated under Subsection 106.02.

Construction or rehabilitation of stone masonry will be evaluated under Subsections 106.02 and 106.04.

Minor concrete will be evaluated under Section 601.

Excavation and backfill will be evaluated under Section 209.

Measurement

620.12 Measure the Section 620 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring stone masonry by the cubic yard (cubic meter), measure in the structure.

When measuring stone masonry guardwall, measure along the gutterline including terminal sections.

When measuring remove and reset stone masonry by the cubic yard (cubic meter), measure in the structure after resetting.

When measuring repointing of stone masonry, measure along the centerline of joint.

Do not measure test wall sections not incorporated in the work.

Payment

620.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 620 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 621. — MONUMENTS AND MARKERS

Description

621.01 This work consists of constructing and reestablishing monuments and markers.

Material

621.02 Conform to the following Section and Subsections:

Minor concrete	601
Reinforcing steel	709.01

Construction Requirements

621.03 Monuments and Markers. Reestablish or locate permanent points according to Subsection 107.01 and Section 152. Excavate and backfill according to Section 209. Monuments may be cast-in-place or precast according to Section 601. Set each monument and marker vertically at the required location and elevation such that the monument remains stable horizontally and vertically. Unless otherwise shown in the plans, install markers or monuments that are commercially available and typical for the area and application. Mark the monuments with durable markings that identify the monument uniquely and unambiguously.

621.04 Acceptance. Material (except concrete for monuments and markers) will be evaluated under Subsections 106.02 and 106.03.

Construction of monuments and markers will be evaluated under Subsections 106.02 and 106.04.

Location of permanent points will be evaluated under Sections 107 and 152.

Structural excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Measurement

621.05 Measure the Section 621 pay items listed in the bid schedule according to Subsection 109.02.

Payment

621.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 621 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 622. — RENTAL EQUIPMENT

Description

622.01 This work consists of furnishing and operating equipment for construction work ordered by the CO and not otherwise provided for under the contract.

Construction Requirements

622.02 Rental Equipment. The CO will order in writing rental equipment for use on the project. Submit the model number and serial number for each piece of equipment before use. Make equipment available for inspection and approval before use.

Furnish and operate equipment with auxiliary attachments and oilers as are usually needed for efficient operation of the equipment. Keep the equipment in good repair and capable of operating 90 percent of the working time.

Obtain approval of the length of workday and workweek before beginning work. Keep daily records of the number of unit-hours of operation. Submit the records along with certified copies of the payroll.

622.03 Acceptance. Rental equipment work will be evaluated under Subsections 106.02 and 106.04.

Measurement

622.04 Measure the Section 622 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure time for moving equipment between project work sites. Do not measure nonoperable equipment or equipment dependent upon another piece of nonoperable equipment.

Payment

622.05 The accepted quantities will be paid at the contract price per unit of measurement for the Section 622 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 623. — GENERAL LABOR

Description

623.01 This work consists of furnishing workers and hand tools for construction work ordered by the CO and not otherwise provided for under the contract.

Construction Requirements

623.02 Workers and Equipment. Furnish competent workers and appropriate hand tools for the work.

Obtain approval of the length of workday and workweek before beginning work. Keep daily records of the number of hours worked. Submit the records along with certified copies of the payroll.

623.03 Acceptance. General labor work will be evaluated under Subsections 106.02 and 106.04.

Measurement

623.04 Measure the Section 623 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure time for workers transportation to and from the project site.

Payment

623.05 The accepted quantities will be paid at the contract price per unit of measurement for the Section 623 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 624. — TOPSOIL

Description

624.01 This work consists of furnishing and placing topsoil and placing conserved topsoil.

Material

624.02 Conform to the following Subsection:

Topsoil	713.01

Construction Requirements

624.03 Preparing Areas. Shape slopes and disturbed areas to be covered with topsoil. Disk or scarify slopes 1V:3H or flatter to a depth of 4 inches (100 millimeters) perpendicular to the natural flow of water.

624.04 Placing Topsoil. Provide at least 7 days notice before the start of topsoil placement. Do not place topsoil when the ground or topsoil is frozen, excessively wet, or otherwise in a condition detrimental to the work. Use conserved topsoil before furnishing topsoil. Keep the roadway surfaces clean during hauling and spreading operations.

Spread topsoil to a depth that after settlement, provides the required depth. Break clods and lumps with harrows, disks, or other appropriate equipment to provide a uniform textured soil. Remove and dispose of clods and stones larger than 2 inches (50 millimeters), stumps, roots, and other litter according to Subsection 203.05.

Construct longitudinal depressions at least 2 inches (50 millimeters) deep perpendicular to the natural flow of water without overly compacting the topsoil surface.

624.05 Acceptance. Material for furnished topsoil will be evaluated under Subsections 106.02 and 106.03.

Material for conserved topsoil will be evaluated under Subsection 106.02.

Placing topsoil will be evaluated under Subsections 106.02 and 106.04.

Measurement

624.06 Measure the Section 624 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring furnishing and placing topsoil by the cubic yard (cubic meter), measure in the hauling vehicle or by the acre (hectare) on the ground surface.

When measuring placing conserved topsoil by the cubic yard (cubic meter), measure in the hauling vehicle or by the acre (hectare) on the ground surface.

Payment

624.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 624 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 625. — TURF ESTABLISHMENT

Description

625.01 This work consists of soil preparation, watering, fertilizing, seeding, and mulching.

Seeding and mulching methods are designated as dry or hydraulic.

Material

625.02 Conform to the following Subsections:

Agricultural limestone	713.02
Fertilizer	713.03
Mulch	713.05
Seed	713.04
Tackifiers	713.11
Water	725.01(b)

Construction Requirements

625.03 General. Apply turf establishment to finished slopes and ditches within 14 days after completion of construction on a portion of the site when approved by the CO. Do not seed during windy weather or when the ground is excessively wet, frozen, snow covered, extremely dry, cloddy, hard pan, or not friable.

625.04 Preparing Seedbed. Grade the seeding area to line and grade. Remove weeds, sticks, stones 2 inches (50 millimeters) in diameter and larger, and other debris detrimental to application, growth, or maintenance of the turf.

Apply limestone and grub proofing if specified.

Cultivate the seeding area to a minimum depth of 4 inches (100 millimeters) and prepare a firm, but friable seedbed before seeding. Do not cultivate aggregate-topsoil courses that were previously dry seeded under Section 313.

625.05 Watering. Moisten seeding areas before seeding and maintain the moisture until turf is established or until final acceptance.

625.06 Fertilizing. Apply fertilizer by the following methods:

(a) Dry method. Incorporate the fertilizer into the upper portion of the seedbed before seeding; or

(b) Hydraulic method. Add fertilizer to the slurry and mix before adding seed. Apply the seed and fertilizer in one application.

625.07 Seeding. Apply seed by the following methods:

(a) Dry method. Apply the seed with approved power driven seeders, drills, or other mechanical equipment. Hand-operated seeding methods are satisfactory on areas inaccessible to mechanical equipment; or

(b) Hydraulic method. Use hydraulic-type equipment capable of providing a uniform application using water as the carrying agent. Add a tracer material consisting of either wood or grass cellulose fiber mulch to the water. Apply the tracer material at a rate of 400 pounds per acre (450 kilograms per hectare) to provide visible evidence of uniform application. Add the seed to the water slurry no more than 30 minutes before application. Seed by hand areas inaccessible to seeding equipment.

625.08 Mulching. If wood chips are used, do not import without approval from the CO. Apply mulch within 48 hours after seeding by the following methods:

(a) Dry method. Spread mulch material, except wood and grass cellulose fibers, by a mulch spreader utilizing forced air to blow the mulch material onto the seeded area. Apply straw mulch at a rate of 3200 pounds per acre (3600 kilograms per hectare). Anchor the mulch material with an approved tackifier or approved mechanical method. Do not mark or deface structures, pavements, utilities, or plant growth with tackifier; or

(b) Hydraulic method. Apply mulch in a separate application from the seed using hydraulic-type equipment according to Subsection 625.07(b).

Apply wood fiber or grass straw cellulose fiber mulch at a rate of 1500 pounds per acre (1700 kilograms per hectare).

Apply bonded fiber matrix hydraulic mulch at a minimum rate of 3000 pounds per acre (3400 kilograms per hectare). Apply so no hole in the matrix is greater than 0.04 inches (1 millimeter). Apply so that no gaps exist between the matrix and the soil.

Mulch by hand areas inaccessible to mulching equipment.

625.09 Protecting and Caring for Seeded Areas. Protect and care for seeded areas including watering when needed. Repair or apply supplemental applications of seed, mulch, fertilizer, and water as many times as needed until turf is established or final acceptance.

625.10 Acceptance. Material for turf establishment will be evaluated under Subsections 106.02 and 106.03.

Placing of turf establishment will be evaluated under Subsections 106.02 and 106.04.

Measurement

625.11 Measure the Section 625 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring turf establishment and supplemental applications by the acre (hectare), measure on the ground surface.

When measuring water by volume or mass, measure in the hauling vehicle or by metering.

Payment

625.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 625 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 626. — PLANTS, TREES, SHRUBS, VINES, AND GROUNDCOVERS

Description

626.01 This work consists of furnishing and planting trees, shrubs, vines, groundcovers, and other plants.

Material

626.02 Conform to the following Subsections:

Fertilizer	713.03
Miscellaneous planting material	713.08
Mulch	713.05
Plant material	713.06
Topsoil	713.01
Water	725.01(b)

Construction Requirements

626.03 General. Do not plant in frozen ground, when snow covers the ground, or when the soil is saturated, extremely dry, cloddy, hard pan, not friable, or is otherwise unsatisfactory for planting.

Furnish stock with a live and fibrous root system. Do not provide container-grown stock that is pot-bound, has a top system out of proportion (larger) than the size of the container, has rooting media that does not hold together when plant is removed from the container, or has roots growing out of the container.

Tag each plant or groups of plants with a weatherproof tag showing species name and date of delivery.

Install plants received on site within 7 days.

626.04 Delivery. Notify the CO 30 days before delivery of material to permit the CO the opportunity to select material at the source. Submit commercial certifications and complete written information concerning the source of supply for plant material at least 14 days before delivery of plants to the project.

626.05 Protection and Temporary Storage. Package plants to provide protection against weather and breakage during transit. Tie and cover plants to prevent wind damage and dehydration when transporting by open vehicle. Pack and ventilate plants to prevent sweating when transporting by closed vehicle. Keep bare root plants below 35 °F (2 °C) during transport.

Keep growing media moist. Protect bark, branches, and root systems from damage. Replace damaged plants including plants with cracked or crushed root balls.

Protect plants not scheduled for immediate planting as follows:

(a) Keep bare root plants below 35 °F (2 °C);

(b) Cover the earth balls of balled and burlapped plants with mulch or other suitable material and keep moist;

(c) Protect container-grown plants from over-exposure to sunlight and keep moist; and

(d) Protect plants from animals and insects.

626.06 Excavation for Plant Pits and Beds. At least 14 days before planting, submit planting locations and methods of planting for approval. Mark planting locations with stakes or flagging. Remove sod, weeds, roots, and other unsuitable material from the planting site. Excavate plant pits as follows:

(a) Width of excavation.

(1) For root spread or ball diameters up to 48 inches (1200 millimeter), dig the pits circular in outline to the root spread plus 24 inches (600 millimeter).

(2) For root spreads or ball diameters over 48 inches (1200 millimeter), excavate one and one-half times the root spread.

(b) Depth of excavation. Dig the pits to a depth that permits at least 6 inches (150 millimeters) of backfill under the roots or balls or dig the pits to the following depths, whichever is deeper:

(1) Deciduous trees.

(a) Under 1½-inch (38 millimeters) caliper	24 inches (600 millimeters) deep
(b) Over1½-inch (38 millimeters) caliper	36 inches (900 millimeters) deep

(2) Deciduous and evergreen shrubs.

(a) Under 2 feet (0.5 meters) height	12 inches (300 millimeters) deep
(b) Over 2 feet (0.5 meters) height	24 inches (600 millimeters) deep

(3) Evergreen trees.

(a) Under 5 feet (1.5 meters) height	8 inches (200 millimeters) plus ball height
(b) Over 5 feet (1.5 meters) height	12 inches (300 millimeters) plus ball height

(4) Vines and groundcovers. Double the size of the pot.

Loosen soil at the sidewalls and bottom of the plant pit to a depth of 6 inches (150 millimeters) before setting the plant.

Do not leave planting holes open overnight.

626.07 Setting Plants. Do not plant material until inspected and approved by the CO. Plants not conforming to specifications, arriving on site in an unsatisfactory condition, or showing sign of improper handling will be rejected. Immediately remove and dispose of rejected plants off site and replace with approved nursery stock.

Prepare a backfill mixture of 4 parts topsoil, loam, or selected soil to one part peat moss. Place backfill mixture in the bottom of the plant pit. Set plants approximately plumb and at the same level or slightly lower than the depth at which they were grown in the nursery or collected in the field. Set plants as follows:

(a) Bare root stock. Place bare rooted plants in the center of the plant pit with the roots properly spread in a natural position. Work backfill mixture around and over the roots, tamp as hole is being filled, and water thoroughly.

(b) Balled and burlapped stock. Handle and move plants by the ball. Place balled and burlapped plants in the prepared pits on tamped backfill mixture. Score the root ball to a depth of 1 inch (25 millimeters) along the entire side equally on 4 sides. Backfill around the plant ball to half the depth of the ball. Tamp and thoroughly water. Cut the burlap and remove it from the upper half of the ball or loosen the burlap and fold it back. If wire baskets are used cut the wire from the upper half of the basket. Backfill the remainder of the plant with backfill mixture.

(c) Container-grown stock. Remove the container just before planting. Place plants in the prepared pits on tamped backfill mixture. Backfill the remainder of the plant with backfill mixture and tamp.

626.08 Fertilizing. Fertilize using either of the following methods:

(a) Mix the fertilizer with the backfill mixture when it is prepared; or

(b) Spread the fertilizer uniformly around the pit area of individual plants or over shrub beds. Cultivate the fertilizer into the top 2 inches (50 millimeters) of the backfill mixture.

626.09 Watering. Construct 4-inch (100-millimeter) deep water basins around trees and 3-inch (75-millimeter) deep water basins around shrubs. Make the diameter of the basin equal to that of the plant pit.

Water plants during and immediately after planting and throughout the plant establishment period. Saturate the soil around each plant at each watering.

626.10 Guying and Staking. When guying and staking is specified, guy deciduous trees just below the first lateral branch and guy evergreen trees half way up the height of the tree. Do not leave the guys and stakes on a tree for more than one growing season.

626.11 Pruning. Prune before or immediately after planting to preserve the natural character of each plant. Use experienced personnel to perform the pruning. Use accepted horticultural practice. Paint cuts over ¾ inch (19 millimeters) in diameter with tree wound dressing.

626.12 Mulching. Remove weeds and other live vegetation from pit and water basin areas around individual plants and from entire shrub beds. If wood chips are used, do not import without approval from the CO. Place mulch within 24 hours after planting.

626.13 Plant Establishment Period. The plant establishment period is a 1-year period beginning at the completion of the project. Employ necessary means to preserve the plants in a healthy growing condition during the plant establishment period. Water, weed, prune, adjust guys and stakes, and protect from animals, insects and disease during the plant establishment period. At the end of the plant establishment period, remove guys and stakes.

626.14 Acceptance. Material for plants, trees, shrubs, vines, and groundcovers (including fertilizer, mulch, and topsoil) will be evaluated under Subsections 106.02 and 106.03.

Planting of plants, trees, shrubs, vines, and groundcovers will be evaluated under Subsections 106.02 and 106.04 and as follows:

An inspection of the plant material will be made about 15 days before the end of the plant establishment period to identify dead, dying, or diseased plants for removal and replacement. During the following planting season, remove and replace identified plants according to this Section. A final inspection of all plant material within 15 days after completion of all replacement planting will be the basis for final acceptance.

Measurement

626.15 Measure the Section 626 pay items listed in the bid schedule according to Subsection 109.02.

Payment

626.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 626 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for plants will be paid as follows:

(a) 75 percent of the pay item amount will be paid following initial planting.

(b) The remaining 25 percent of the pay item amount price will be paid after the final inspection.

Section 627. — SOD

Description

627.01 This work consists of furnishing and placing living sod of perennial turf-forming grasses**.**

Material

627.02 Conform to the following Subsections:

Agricultural limestone	713.02
Fertilizer	713.03
Pegs for sod	713.10
Sod	713.09
Water	725.01(b)

Construction Requirements

627.03 General. Move and lay sod during dry weather and on dry, unfrozen ground.

Avoid erosion when watering.

627.04 Delivery. Provide at least 3 days notice before cutting sod. The CO will approve the sod in its original position before cutting. Do not deliver sod until the soil is prepared.

627.05 Preparing the Soil. Clear and grade the surface. Cultivate, disk, harrow, or otherwise loosen the grade to a depth of at least 4 inches (100 millimeters). Finish the surface to a smoothness comparable to hand raking. Remove surface stones not passing a 1-inch (25-millimeter) sieve, sticks, stumps, and other surface debris interferes with sod placement or subsequent growth.

Place topsoil according to Section 624.

Apply fertilizer and agricultural limestone uniformly over the sodding area. Mechanical spreaders or blower equipment may be used. Disk or till the fertilizer and limestone into the soil to a depth of 4 inches (100 millimeters).

Moisten the prepared soil.

627.06 Placing Sod. Place sod within 24 hours after cutting or within 5 days after cutting when the sod is stored in moist stacks, grass-to-grass and roots-to-roots. Protect sod against drying and from freezing.

(a) Solid sod. Place sod perpendicular to drainage flows. Place sections of solid sod edge to edge with staggered joints. Plug openings with sod or fill openings with acceptable loamy seeded topsoil. Roll or tamp sod to eliminate air pockets and provide an even surface. On slopes 1V:2H or steeper and in channels, peg sod on 24-inch (600-millimeter) centers after rolling or tamping. Drive pegs flush with the sod bed surface.

(b) Strip sod. Lay strip sod in shallow trenches in parallel rows. Firmly roll or tamp until the surface of the sod is level with or below the adjacent soil. Seed the soil between the strips of sod according to Section 625. Rake or drag the seeded areas to cover the seed.

(c) Spot sod. Place sod blocks. Roll or tamp the blocks into the soil until the sod surfaces are slightly below the surrounding ground surface.

Blend final grades with existing adjacent areas. Leave the entire area drainable and without abrupt changes in slope.

627.07 Maintaining Sodded Areas. Water sod to a depth of 4 inches (100 millimeters) after placing and keep moist.

Protect newly sodded areas using methods approved by the CO. Do not allow wheeled vehicles on newly sodded areas.

Mow sodded areas and repair or replace sodded areas that are damaged or fail to show a uniform growth of grass. Maintain sodded areas and replace nonliving sod until final acceptance of the project.

627.08 Acceptance. Material for sod (including lime and fertilizer) will be evaluated under Subsections 106.02 and 106.03.

Placing sod will be evaluated under Subsections 106.02 and 106.04.

Topsoil will be evaluated under Section 624.

Measurement

627.09 Measure the Section 627 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure non-sodded areas adjacent to strip and spot sodding.

Measure topsoil under Section 624.

Measure water and seeding under Section 625.

Payment

627.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 627 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 628. — RESERVED

Section 629. — ROLLED EROSION CONTROL PRODUCTS AND CELLULAR CONFINEMENT SYSTEMS

Description

629.01 This work consists of constructing temporary and permanent installations to control erosion and enhance vegetation establishment and survivability on slopes and channels. This work also includes installing rolled erosion control products (RECP) and cellular confinement systems.

RECP are designated according to Subsections 713.17, 713.18, and the following:

(a) Mulch control netting. A planar woven natural fiber or extruded geosynthetic mesh used as a temporary degradable RECP to anchor loose fiber mulches.

(b) Open weave textile. A temporary degradable RECP composed of processed natural or polymer yarns woven into a matrix, used to provide erosion control and facilitate vegetation establishment.

(c) Erosion control blanket. A temporary degradable RECP composed of processed natural or polymer fibers mechanically, structurally or chemically bound together to form a continuous matrix to provide erosion control and facilitate vegetation establishment.

(d) Turf reinforcement mat. A permanent non-degradable RECP designed for critical hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation. Turf reinforcement mats provide sufficient thickness, strength, and void space to permit soil filling and retention and the development of vegetation within the matrix. Turf reinforcement mats are typically used in hydraulic application (such as high flow ditches and channels, steep slopes, stream banks, and shorelines) where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated. Turf reinforcement mats may be supplemented with degradable components to provide immediate and permanent erosion protection and vegetation reinforcement on geotechnically stable slopes.

Cellular confinement system cell depths are designated according to Table 713-2.

Material

629.02 Conform to the following Sections and Subsections:

Cellular confinement systems	713.07
Temporary rolled erosion control products	713.17
Topsoil	624
Turf establishment	625
Turf reinforcement mat	713.18

Construction Requirements

629.03 General. Make the soil surface stable, firm, and free of rocks and other obstructions. Install RECP and cellular confinement systems according to the manufacturer's recommendations and to the following minimum guidelines. Apply turf establishment according to Section 625.

In areas to be mowed soon after installation, use temporary RECP consisting of rapidly degrading netting with a functional longevity of 3 months or less.

629.04 Mulch Control Netting (RECP, Types 1.A, 2.A, and 3.A). Apply mulch according to Subsection 625.08(a). Immediately after mulching, install mulch control netting according to Subsection 629.05.

629.05 Erosion Control Blanket, Open Weave Textile, and Turf Reinforcement Mat (RECP, Types 1.B, 1.C, 1.D, 2.B, 2.C, 2.D, 3.B, 4, 5.A, 5.B, and 5.C). Unless soil in- filling is required, complete turf establishment work before installing RECP.

If soil in-filling is required, first install RECP. Then apply seed and lightly brush or rake ¼ to ¾ inches (6 to 19 millimeters) of topsoil into the voids in the RECP filling the full product thickness.

Use staples that are at least 6 inches (150 millimeters) long to secure the RECP. Longer staples may be necessary in sandy, loose, or wet soils.

Unroll the RECP parallel to the primary direction of flow and place it in direct contact with soil surface. Do not stretch or allow RECP to bridge over surface inconsistencies. Overlap edges of adjacent RECP by 2 to 4 inches (50 to 100 millimeters). Use a sufficient number of staples to prevent seam separation. Overlap roll ends of joining RECP 2 to 6 inches (50 to 150 millimeters) in the direction of flow.

(a) Slope installations. At the top of slope, anchor the RECP by one of the following methods:

(1) Staples. Install the RECP 36 inches (900 millimeters) over the shoulder of the slope onto flat final grade. Secure with a single row of staples on 12-inch (300-millimeter) centers;

(2) Anchor trench. Construct a 6- by 6-inch (150- by 150-millimeter) trench. Extend the upslope terminal end of the RECP 36 inches (900 millimeters) past the trench. Use staples on 12-inch (300-millimeter) centers to fasten the RECP into the trench. Backfill the trench and compact the soil. Secure the terminal end with a single row of staples on 12-inch (300-millimeter) centers and cover the end with soil. Apply turf establishment; or

(3) Check slot. Install two rows of staples 4 inches (100 millimeters) apart on 4-inch (100-millimeter) centers across the top edge of the RECP. Drive staple heads flush with soil surface.

Securely fasten RECP to the soil by installing staples at a minimum rate of 1.5 per square yard (1.3 per square meter).

(b) Channel installations. At the beginning of the channel, construct a full width anchor trench according to Subsection 629.05(a)(2). Construct additional anchor trenches or check slots at intervals along the channel reach and at the channel end according to Subsection 629.05(a)(2) or (a)(3) and the manufacturer's installation guidelines.

Securely fasten RECP to the soil by installing staples at a minimum rate of 2 per square yard (2 per square meter). Significantly higher anchor rates may be necessary in sandy, loose, or wet soils and in severe applications.

Repair damaged areas immediately by restoring soil to finished grade, re-applying turf establishment, and replacing the RECP.

629.06 Cellular Confinement Systems. Excavate to the depth of the cellular confinement system and smooth and compact the slope. Install the top of the system flush or lower than the adjacent slope. Expand the geocell down the slope. Connect adjacent geocell sections with hog rings or staples in every other cell.

Anchor the system with wooden stakes across the top at every other cell. Repeat the anchoring pattern in every tenth row and in the bottom row. Drive stakes to a minimum embedment of 12 inches (300 millimeters) below the base of the cellular confinement layer.

Backfill the system with topsoil. Hand-compact the topsoil within each cell and apply turf establishment.

629.07 Acceptance. Material for RECP and cellular confinement system will be evaluated under Subsections 106.02 and 106.03.

Installation of RECP and cellular confinement systems will be evaluated under Subsections 106.02 and 106.04.

Topsoil will be evaluated under Section 624.

Turf establishment will be evaluated under Section 625.

Measurement

629.08 Measure the Section 629 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure topsoil under Section 624.

Measure turf establishment under Section 625.

Payment

629.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 629 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 630. — RESERVED

Section 631. — RESERVED

Section 632. — RESERVED

Section 633. — PERMANENT TRAFFIC CONTROL

Description

633.01 This work consists of installing and removing and resetting permanent traffic control devices.

Sign panels are designated as plywood, steel, aluminum, plastic, fiberglass reinforced plastic, or extruded aluminum.

Sign posts are designated as wood, aluminum, galvanized steel, or corrosion resistant steel.

Material

633.02 Conform to the MUTCD and the following Section and Subsections:

Delineator and object marker retroreflectors	718.08
Hardware	718.06
Legends and borders	718.07
Minor concrete	601
Object marker and delineator posts	718.05
Panels	718.03
Retroreflective sheeting	718.01
Sign posts	718.04

Construction Requirements

633.03 General. Furnish and install permanent traffic control devices according to the MUTCD and permanent traffic control plans. Provide traffic control devices that are crashworthy.

Sign locations may be changed to fit field conditions as approved by the CO. Determine sign support lengths at time of staking.

633.04 Sign Posts. Install sign posts plumb and according to the manufacturer's recommendations.

Drive sign posts with a suitable driving head or set posts in drilled or punched holes.

Excavate, construct, and backfill concrete footings according to Section 601.

633.05 Sign Panels.

(a) Fabrication.

(1) Panels. Cut panels to dimension shown and place holes before applying retroreflective material. Do not field drill holes in panels.

Clean and degrease the face of the metal panels using methods recommended by the retroreflective sheeting manufacturer before applying retroreflective sheeting.

Wipe plastic panels clean with a slightly dampened cloth before applying retroreflective sheeting.

Abrade, clean, and degrease the face of the plywood panels using methods recommended by the retroreflective sheeting manufacturer before applying reflective sheeting. Treat plywood panel edges with sealant.

Join extruded aluminum panel sections with panel nuts, bolts, and washers to achieve the desired sign size. Use 6- and 12-inch (150- and 300-millimeter) plate heights to achieve the sign panel vertical dimensions in increments of 6 inches (150 millimeters). Do not include more than one 6-inch (150-millimeter) plate per sign.

Use retroreflective sheeting as specified and according to ASTM D4956. For roadside signs, use Type III, IV, VIII, IX, or XI prismatic retroreflective sheeting. Use fluorescent yellow sheeting for warning signs. Use fluorescent yellow-green sheeting for pedestrian, bicycle, and school crossing signs.

For multilane or overhead guide signs, use Type III or Type IV prismatic retroreflective sheeting for the background and Type IX or Type XI retroreflective sheeting for the legend.

For parking lot and non-roadway signs, Types I and Type II retroreflective sheeting may be used.

(2) Legends and borders. Form letters, numerals, and other units to provide a continuous stroke width with smooth edges. Make the surface flat and free of warp, blisters, wrinkles, burrs, and splinters. Do not fabricate letters, numerals, arrows, symbols, or borders using a red screen ink process.

Conform to one of the following techniques:

(a) Type L-1 (screen process). Apply letters, numerals, arrows, symbols, borders, and other features on the sign background by direct or reverse screen process. Apply messages and borders of a color darker than the sign background by the direct process. Apply messages and borders of a color lighter than the sign background by the reverse screen process.

Apply screen inks recommended by the ink manufacturer for use on the various types of retroreflective sheeting. Apply ink that has the same durability and color as specified for that type of retroreflective sheeting. Apply black screen ink until opaque on retroreflective sheeting.

Perform the screening in a manner to ensure a uniform color and tone, with sharply defined edges of legends and borders. Do not allow running, streaking, or sagging.

Air dry or bake the signs after screening according to manufacturer’s recommendations to provide a smooth hard finish.

(b) Type L-2 (transparent films). Apply letters, numerals, arrows, symbols, borders, and other features on the sign background with colored transparent films. Select durable, electronically cuttable films coated with a transparent pressure-sensitive adhesive protected by a removable liner. Use transparent films recommended by the manufacturer within the color requirements specified for the retroreflective sheeting.

(c) Type L-3 (direct applied characters). Cut letters, numerals, arrows, symbols, borders, and other features from black opaque or retroreflective sheeting of the color specified. Apply characters to the sign background according to the retroreflective sheeting manufacturer’s instructions. Use the same sheeting manufacturer for both the sign legend, border, and background.

Package sign panels in protective material and transport in a vertical position.

(b) Installation. Mount sign panels with the legend horizontal.

Use oversized bolt heads and neoprene or nylon washers for fastening plastic sign panels. Use antitheft fasteners where possible. Paint bolt heads, screw heads, and washers that are exposed on the sign face. Match the color of the paint to the color of the sheeting at the point where the fitting is exposed.

Turn sign panels 3 degrees away from the road in the direction of travel to reduce specular glare (mirror reflection).

Cover the sign face with an opaque material if a sign message is not applicable. Maintain the covering in good condition until the message becomes applicable. Do not use adhesive tape on the sign face.

633.06 Delineators and Object Markers. Attach delineators and object markers to posts according to the manufacturer's recommendation or as specified.

633.07 Removing and Resetting Permanent Traffic Control Devices. Remove and store existing traffic control devices to be reset as necessary. Replace traffic control devices damaged during removal, storage, and resetting.

633.08 Acceptance. Material for permanent traffic control devices will be evaluated under Subsections 106.02 and 106.03.

Installation of permanent traffic control devices will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Measurement

633.09 Measure the Section 633 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring sign panels by the square foot (square meter), measure front face. Measure each sign panel in a multiple configuration.

When measuring sign systems by the square foot (square meter), measure front face of each sign panel.

When measuring sign systems by the each, measure each system as one regardless of the number of sign panels.

A sign system includes the supports.

When measuring removing and resetting permanent traffic control device, measures after they are reset. Measure removing and resetting of sign systems as described above.

Payment

633.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 633 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 634. — PERMANENT PAVEMENT MARKINGS

Description

634.01 This work consists of applying paint, markings, and markers on finished pavement.

Pavement markings are designated as follows:

Type A – Solventborne traffic paint with Type 1 glass beads;

Type B – Waterborne traffic paint with Type 1 glass beads;

Type C – High-build waterborne traffic paint with Type 1 and Type 3 glass beads;

Type D – Epoxy markings with Type 1 glass beads;

Type E – Epoxy markings with Type 1 and Type 3 glass beads;

Type H – Thermoplastic markings with Type 1 glass beads;

Type I – Thermoplastic markings with Type 1 and Type 3 glass beads;

Type J – Preformed pavement marking tape; or

Type K – Nonreflectorized markings.

Material

634.02 Conform to the MUTCD and the following Subsections:

Epoxy markings	718.11
Epoxy resin adhesives	718.17
Glass beads	718.14
Pavement markers	718.15
Preformed pavement marking tape	718.13
Solventborne traffic paint	718.09
Thermoplastic markings	718.12
Waterborne traffic paint	718.10

Construction Requirements

634.03 General. Where existing and final pavement marking locations are identical, stake the limits of existing pavement markings before beginning pavement work.

Submit manufacturer's MSDS and product data sheets at least 7 days before applying pavement markings. A field demonstration may be required to verify the adequacy of the material.

Ship marking material in suitable containers plainly marked with the following information as appropriate for the material being furnished:

(a) Manufacturer's name and address;

(b) Name of product;

(c) Lot and batch numbers;

(d) Color;

(e) Net mass and volume of contents;

(f) Date of manufacture;

(g) Date of expiration;

(h) Statement of contents (if mixing of components is required);

(i) Mixing proportions and instructions; and

(j) Safety information.

Establish marking patterns or locations according to the MUTCD, plans, or state requirements. In curve widening areas, establish the edge line markings at the limits of the traveled way and the centerline markings equal distance between the edge lines.

Remove loose particles, dirt, tar, grease, and other deleterious material from the surface to be marked. Where markings are placed on rigid pavement less than 1-year old, clean the pavement of laitance and curing compounds.

Remove temporary pavement markings the same day permanent pavement markings are applied. Remove temporary and conflicting pavement makings according to Subsection 635.13 before applying permanent pavement markings.

Obtain approval before applying markings. Apply markings to a clean, dry surface, and according to the manufacturer's recommendations. Produce markings that are clean-cut and uniform in appearance by day and night.

Current state approved pavement marking material may be used, when approved by the CO. Submit proof of compliance with state specifications.

Apply glass beads immediately following paint or markings application to ensure adhesion.

Protect markings from traffic until dried to a no-tracking condition. Remove tracking marks, spilled marking material, markings in unauthorized areas, and defective markings.

634.04 Solventborne Traffic Paint (Type A). Apply paint when pavement and air temperatures are at 35 °F (2 °C) and rising. Do not heat the paint above 120 °F (49 °C). Spray paint at a 15 mil (0.38 millimeters) minimum wet film thickness or at a rate of 107 square feet per gallon (2.6 square meters per liter).

Apply Type 1 glass beads on the paint at a rate of 6 to 8 pounds per gallon (0.72 to 0.96 kilograms per liter) of paint.

On new asphalt pavements or new asphalt surface treatments, apply two applications of paint and glass beads. Apply second application after first application is track free.

634.05 Waterborne Traffic Paint (Type B and Type C). Apply paint when pavement and air temperatures are 50 °F (10 °C) and rising.

(a) Type B. Do not heat the paint above 120 °F (49 °C). Spray paint at a 15 mil (0.38 millimeters) minimum wet film thickness or at a rate of 107 square feet per gallon (2.6 square meters per liter).

Apply Type 1 glass beads on the paint at a rate of 6 to 8 pounds per gallon (0.72 to 0.96 kilograms per liter) of paint.

On new asphalt pavements or new asphalt surface treatments, apply two coats.

(b) Type C. Spray paint at 25 mil (0.63 millimeters) minimum wet film thickness or at a rate of 71 square feet per gallon (1.7 square meters per liter).

Use two bead dispensers. Apply Type 3 glass beads on the paint at a rate of 6 to 8 pounds per gallon (0.72 to 0.960 kilograms per liter) followed by Type 1 glass beads on the paint at a rate of 6 to 8 pounds per gallon (0.72 to 0.96 kilograms per liter) of paint.

634.06 Epoxy Markings (Types D and Type E). Apply epoxy when pavement and air temperatures are 35 °F (2 °C) and rising. Heat components as specified by the manufacturer. Apply at a 25 mil (0.63 millimeters) minimum dry film thickness or at a rate of 71 square feet per gallon (1.7 square meters per liter).

(a) Type D. Apply Type 1 glass beads on the epoxy at a rate of 6 to 8 pounds per gallon (0.72 to 0.96 kilograms per liter) of epoxy.

(b) Type E. Use two bead dispensers. Apply Type 3 glass beads on the epoxy at a rate of 6 to 8 pounds per gallon (0.72 to 0.96 kilograms per liter) of epoxy followed by Type 1 glass beads on the epoxy at a rate of 6 to 8 pounds per gallon (0.72 to 0.96 kilograms per liter) of epoxy.

634.07 Thermoplastic Markings (Type H and Type I). Apply thermoplastic when pavement and air temperatures are 50 °F (10 °C) and rising. Heat thermoplastic as specified by the manufacturer.

Apply an epoxy resin primer/sealer according to the thermoplastic manufacturer's recommendations when placing markings on rigid pavements or asphalt pavements more than 2-years old, oxidized, or having exposed aggregates.

Allow the primer/sealer to dry.

For edge lines, apply thermoplastic at 60 mil (1.5 millimeters) dry film thickness. For other lines, apply thermoplastic at 90 mil (2.3 millimeters) dry film thickness.

(a) Type H. Apply Type 1 glass beads on the thermoplastic at a rate recommended by the manufacturer.

(b) Type I. Use two bead dispensers. Apply Type 3 glass beads on the thermoplastic followed by Type 1 glass beads on the thermoplastic at rates recommended by the manufacturer.

634.08 Preformed Pavement Marking Tape (Type J). Install to form a durable, weather resistant bond to the pavement. Apply preformed markings according to the manufacturer's recommendations. Use preformed marking tape containing retroreflective beads.

634.09 Nonreflectorized Markings (Type K). Apply solvent borne or waterborne traffic paint without glass beads.

634.10 Pavement Markers. Install raised or recessed pavement markers when the pavement and air temperatures are 50 °F (10 °C) and rising. Apply pavement markers with an epoxy resin adhesive as recommended by the manufacturer when the pavement is dry. Space the markers according to the MUTCD and plans.

634.11 Acceptance. Material for permanent pavement markings will be evaluated under Subsections 106.02 and 106.03.

Placing of permanent pavement markings will be evaluated under Subsections 106.02 and 106.04.

Measurement

634.12 Measure the Section 634 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When pavement markings are measured by the linear foot (meter), measure the length of line applied along the centerline of each line applied regardless of color. Measure broken or dotted pavement lines from end to end of the line including gaps. Measure solid pavement lines from end to end of each continuous line. Measure line quantities based on a 4-inch (100-millimeter) wide line. For line widths greater than 4 inches (100 millimeters), adjust the measured length of line in the ratio of the required width to 4 inches (100 millimeters).

When pavement markings are measured by the square foot (square meter), measure the number of square feet (square meter) of line, symbol or letter marking based on the marking area shown in the plans. If not shown, measure the area of each marking in place to the nearest square foot (square meter).

Payment

634.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 634 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 635. — TEMPORARY TRAFFIC CONTROL

Description

635.01 This work consists of furnishing, installing, maintaining, relocating, and removing temporary traffic control devices and services as ordered for the control and protection of public traffic through the project.

Advance warning arrow board, barricade, and warning light types are designated in the MUTCD.

Material

635.02 Conform to the MUTCD and the following Sections and Subsections:

Concrete barrier (temporary)	618
Delineator and object marker retroreflectors	718.08(b)
Guardrail (temporary)	617
Retroreflective sheeting	718.01
Sign panels	633.05
Sign posts	633.04
Temporary plastic fence	710.11
Temporary pavement markings	718.16

Construction Requirements

635.03 Qualifications. Provide flaggers certified by ATSSA, the National Safety Council, a state department of transportation, or other acceptable organization. Use pilot car operators conforming to the qualifications of a flagger.

635.04 General. Furnish, install, and maintain temporary traffic control devices adjacent to and within the project as required by the MUTCD, traffic control plan, and Section 156. Install and maintain traffic control devices as follows:

(a) Furnish and install traffic control devices before the start of construction operations;

(b) Install only those traffic control devices needed for each stage or phase;

(c) Relocate temporary traffic control devices as necessary;

(d) Remove devices that no longer apply to the existing conditions;

(e) Immediately replace devices that are lost, stolen, destroyed, or inoperative;

(f) Keep temporary traffic control devices clean;

(g) Furnish and maintain traffic control devices that meet the "*acceptable*" standard described in ATSSA, *Quality Standards for Work Zone Traffic Control Devices*. Amend the ATSSA standards as follows:

(1) Repair or remove and replace "*marginal*" devices within 48 hours; and

(2) Repair or remove and replace "*unacceptable*" devices immediately;

(h) Remove temporary traffic control devices upon contract completion or when approved; and

(i) Furnish crashworthy temporary traffic control devices.

635.05 Barricades. Use barricades of the type and size specified or according to the MUTCD. Use Type III, IV, IX, or XI retroreflective sheeting.

635.06 Cones and Tubular Markers. Use cones or tubular markers of the height specified or according to the MUTCD. Use Type III or Type VI retroreflective sheeting.

635.07 Construction Signs. Use Type III, IV, VIII, IX, or XI prismatic retroreflective sheeting. Use fluorescent sheeting for orange signs. For roll-up signs, use florescent Type VI retroreflective sheeting.

Install posts according to Section 633. Portable sign supports may be used instead of sign posts when approved by the CO.

Remove or completely cover unnecessary signs. Use metal, plywood, or other acceptable material to cover signs. Do not use adhesives glues, tapes, or mechanical fasteners that mar the face of the panel of the sign to be covered.

635.08 Drums. Use plastic drums that are at least 36 inches (900 millimeters) high and at least 18 inches (450 millimeters) in diameter. Use Type III or Type VI retroreflective sheeting.

635.09 Flaggers. Use flaggers certified according to Subsection 635.03. Use Type III, IV, VIII, IX, or XI retroreflective sheeting on flagger paddles. Do not use flags.

635.10 Pilot Cars. Use pilot car operators certified according to Subsection 635.03. Mount a "*PILOT CAR FOLLOW ME*" sign on the rear and a high-intensity, rotating, flashing, oscillating, or strobe light on the roof of the pilot car.

635.11 Temporary Barriers. Use temporary barriers that are crashworthy and are new or used provided they are not badly damaged. Lifting holes no larger than 4 inches (100 millimeters) or lifting loops are permitted.

Mount white or yellow retroreflectors as applicable, to the top or side of the barrier on 25-foot (8-meter) centers. Mount the retroreflectors at a uniform height at least 24 inches (600 millimeters) above the road surface. Flexible barrier delineators or barrier delineation tape may be used instead of retroreflectors when approved by the CO.

635.12 Temporary Guardrail. Construct temporary guardrail according to Section 617.

Mount white or yellow retroreflectors as applicable, to the top or side of the guardrail on 25-foot (8-meter) centers. Mount the retroreflectors at a uniform height at least 24 inches (600 millimeters) above the road surface.

635.13 Temporary Pavement Markings and Delineation. Before opening a pavement surface to traffic, remove conflicting pavement markings by sandblasting or other methods that do not damage the surface or texture of the pavement. Make the removal pattern uneven to not perpetuate the outline of the removed pavement markings. Lightly coat sandblasted or removal areas on asphalt surfaces with emulsified asphalt.

Place and maintain temporary pavement markings that are neat, crack free, true, straight, and unbroken.

If temporary signs and pavement markers are substituted for temporary pavement markings, install temporary signs and pavement markers according to the MUTCD and plans.

For temporary pavement markings, use preformed retroreflective tape, traffic paint, or pavement markers as follows:

(a) Preformed retroreflective tape. Apply according to the manufacturer's instructions. Remove loose preformed retroreflective tape before placing additional pavement layers.

(b) Pavement markers. Do not use pavement markers during seasonal suspensions. When chip seals, slurry seals, or tack coats are used after marker placement, protect the markers with an approved protective cover, and remove it after the asphalt material is sprayed.

(c) Traffic paint. Do not apply traffic paint to the final surface. Apply traffic paint as the temporary pavement marking if no work will be performed on the project for at least 30 consecutive days. Apply traffic paint at a 15 mil (0.38-millimeter) minimum wet film thickness or at a rate of 107 square feet per gallon (2.6 square meters per liter). Immediately apply Type 1 glass beads on the paint at a minimum rate of 6 pounds per gallon (0.7 kilograms per liter) of paint.

Remove temporary pavement markers before placing additional pavement layers or permanent pavement markings. Remove temporary markings after 14 days and apply permanent pavement markings unless approved by the CO.

635.14 Vertical Panels. Use vertical panels that are at least 24 inches (600 millimeters) in height and 8 to 12 inches (200 to 300 millimeters) wide. Use Type III, IV, VIII, IX, or XI retroreflective sheeting.

635.15 Warning Lights. Use warning lights of the types shown in the plans or according to the MUTCD. Install warning lights with a minimum mounting height of 30 inches (750 millimeter) to the bottom of the lens. Secure lights to the top of the traffic control device they are supplementing. Use batteries recommended by the light manufacturer. Mount large batteries below windshield height and preferably on the ground. Replace batteries when they no longer provide satisfactory performance.

Use Type C steady-burn warning lights for delineation on barricades or drums. Use Type A low-intensity flashing warning lights on the first 2 barricades or drums in the merging or shifting taper series. Use Type B high-intensity flashing warning lights on the first two advance warning signs. Type A and Type C warning lights are intended to warn road users during nighttime hours, while Type B warning lights are intended to warn road users during both daylight and nighttime hours.

635.16 Shadow Vehicle. Use a 19,800 pound (9000-kilogram) ± 990 pound (±450 kilogram) shadow vehicle equipped with a truck-mounted attenuator (crash cushion) attached to the rear of the vehicle, exterior flashing yellow dome light, and an arrow board.

Use the shadow vehicle to provide physical protection to workers from traffic approaching from the rear during moving operations.

Use the following procedures to close a lane of traffic:

(a) Move the shadow vehicle to a point approximately 200 feet (60 meters) from the first advance warning sign for the lane closure and stop on the shoulder;

(b) Activate the flashing lights and flashing arrow board. Begin the arrow board in the caution mode and after approximately 2 minutes display the correct flashing pass arrow;

(c) Move the shadow vehicle (now acting as a protection vehicle) along the shoulder to the first sign location, stopping approximately 100 feet (30 meters) before the sign location in a blocking position;

(d) Place the first sign then proceed to the next advance sign location. Repeat step (c) for the second sign and install that sign. Repeat this procedure until advance warning signs are installed;

(e) After installing the advanced warning signs for the lane closure, move the shadow vehicle into the lane that is to be closed to a position 100 feet (30 meters) before the closing taper location. Install the channelizing devices for the taper in the shielded lane; then

(f) Move the shadow vehicle off the roadway and past the taper on the shoulder and remain in position until the flashing arrow board for the closure (if one is to be provided) is placed and operating. Move the shadow vehicle with the workers as they proceed to set up the remaining devices as additional protection.

Alternate lane closure procedures may be used if approved by the CO.

635.17 Pavement Patch. Use an asphalt mix according to Section 403 or commercial available cold asphalt mix to repair potholes and rough spots in the traveled way before reopening travel lanes to traffic. If cold asphalt mix is used, remove and replace with hot asphalt mix before placing succeeding hot asphalt lifts.

635.18 Temporary Crash Cushions. Use a crashworthy temporary crash cushion according to manufacturer's recommendations.

635.19 Temporary Signal System. Use a temporary signal system according to MUTCD Parts 4 and 6.

Provide the names and telephone numbers of at least two emergency contacts who can be reached 24 hours a day, and who are available to arrive on site within 4 hours of notification to repair or replace malfunctioning temporary signal equipment. In addition, provide for emergency flaggers who can be reached 24 hours a day, and who are available to perform traffic control operations within the timeframes specified below until the temporary signal system is operable.

If the traffic signal malfunctions during construction operations, immediately begin traffic control operations using flaggers until the system is returned to normal signal operation. Complete traffic signal repairs within 6 hours of the malfunction.

If the traffic signal malfunctions during a period when no construction activity is taking place, begin traffic control operations using flaggers as soon as possible, but no later than 2 hours after the initial notification. Continue temporary flagging operations until the system is returned to normal signal operation. Complete traffic signal repairs within 12 hours of notification.

No payment will be made for the use of flaggers in place of a malfunctioning or inoperable temporary signal system.

635.20 Temporary Fence. Use temporary fence according to Section 619.

635.21 Temporary Rumble Strip. Use transverse or longitudinal rumble strips according to the MUTCD Part 6 to alert drivers of an approaching flagger station or work area.

635.22 Steel Plates. Use 1-inch (25-millimeter) or thicker steel plates capable of safely carrying traffic. Secure the plates to the pavement to prevent movement.

635.23 Acceptance. Material for temporary traffic control devices will be evaluated under Subsections 106.02 and 106.03.

Vehicles for pilot cars and shadow vehicles will be evaluated under Subsections 106.02 and 106.04.

Placement of temporary traffic control devices will be evaluated under Subsections 106.02 and 106.04.

Temporary traffic control services will be evaluated under Subsections 106.02 and 106.04.

Measurement

635.24 Measure the Section 635 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable when ordered by the CO and installed.

When measuring temporary traffic control pay items, measure only one time even if relocated or replaced, except for pay items paid by the hour.

Measure barricades by the linear foot (meter) of width.

When measuring construction signs by the square foot (square meter), measure front face sign panel. Do not measure posts and temporary supports.

When there is a pay item for moving temporary barriers, do not measure movement of temporary barriers for work access or the convenience of the Contractor.

When measuring temporary pavement markings, measure only one application of pavement markings per lift. When temporary pavement markings are measured by the linear foot or mile (meter or kilometer), measure the number of linear feet or miles (meters or kilometers) of lines applied along the centerline of each 4-inch (100-millimeter) wide line applied regardless of color. Measure solid lines from end to end of each continuous line. Measure broken lines from end to end including gaps. For line widths greater than 4 inches 100 millimeters), adjust the measured length of line in the ratio of the required width to 4 inches (100 millimeters). When temporary pavement markings are measured by the square foot (square meter), measure the number of square feet (square meters) of symbols or letter markings based on the marking area shown in the plans or, if not shown, the area of each marking measured in place to the nearest square foot (square meter).

When measuring temporary pavement markers, measure only one application of pavement markings per lift, even if replaced. Measure temporary pavement markers used at the option of the Contractor instead of temporary pavement markings as equivalent temporary pavement markings and not as temporary pavement markers.

When measuring pavement marking removal, measure the actual line removed. Do not measure gaps.

When measuring temporary crash cushions, measure each entire crash cushion configuration.

When there is a pay item for moving temporary crash cushion, do not measure movement of temporary crash cushion for work access or the convenience of the Contractor.

Measure replacement barrels or cartridges for crash cushions for the barrels or cartridges damaged by public traffic.

Payment

635.25 The accepted quantities will be paid at the contract price per unit of measurement for the Section 635 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for temporary traffic control devices will be paid as follows:

(a) 50 percent of the pay item amount will be paid upon installation.

(b) An additional 25 percent of the pay item amount will be paid following completion of 50 percent of the contract amount.

(c) Payment of the remaining portion of the pay item amount will be paid when the temporary traffic control devices are removed from the project.

Progress payments for pay items paid for by the hour will be paid at 100 percent of the pay item amount when ordered by the CO and furnished.

Section 636. — TRAFFIC SIGNAL, TRAFFIC COUNTER, LIGHTING, AND ELECTRICAL SYSTEMS

Description

636.01 This work consists of installing, modifying, relocating, or removing traffic signals, traffic counter, flashing beacons, highway lighting, sign illumination, communication conduits, and electrical systems or provisions for future systems.

Material

636.02 Conform to the following Subsections:

Backer rod	712.01(f)
Electrical material	721.01
Joint sealant and crack fillers	712.01(a)
Lighting material	721.02
Underground concrete utility structures	725.09(d)

Construction Requirements

636.03 Regulations and Codes. Furnish material and workmanship conforming to the standards of the National Electrical Code, local safety code, UL, and the National Electrical Manufacturers Association (NEMA).

Obtain permits, arrange for inspections, and pay fees necessary to obtain electrical service.

Furnish luminaires with crashworthy supports.

Notify the CO, local traffic enforcement agency, utility companies, or railroad company at least 7 days before operational shutdown to coordinate connections or disconnections to an existing utility or system.

636.04 General. At the preconstruction conference, submit a certified cost breakdown for all lump sum items for use in making progress payments and price adjustments.

Submit a list of proposed equipment and material 14 days before installation. Include the manufacturer’s name, size, and identification number of each item. Supplement the list with scale drawings, catalog cuts, and wiring diagrams showing locations and details of equipment and wiring.

The CO will approve the exact locations of the systems.

Remove structures and obstructions according to Section 203. Salvage material acceptable for reuse in the work. Excavate and backfill according to Section 209. Construct concrete according to Section 601.

Where roadways are to remain open to traffic and existing systems will be modified, maintain the existing systems in operation until final connection to the modified circuit to minimize traffic disruptions.

636.05 Conduit. Cut conduit so the ends are smooth. Connect conduit sections with couplings to butt the ends of both conduits squarely against each other inside the couplings. Provide a metal expansion and deflection fitting where conduit crosses a structural expansion joint.

Install conduits continuous between outlets with at least couplings to permit pulling conductors. End conduit with bell fittings or bushings. Furnish pull wires for conduits designated for future cable installation.

Remove and replace crushed, deformed, or damaged conduit. Maintain conduits clean and dry and protect ends of conduit with plugs, caps, or fittings.

Size pull boxes to provide for termination of the conduit and connection of the conductors.

636.06 Traffic Signal and Lighting Systems. Furnish systems according to the MUTCD or state adopted supplements to the MUTCD for the state in which the system is located. Design systems to operate according to NEMA.

Design the control unit to energize the lighting circuit upon failure of any component of its circuit. Furnish a control with an "*on*" level adjustable between 1 and 5 foot candles (11 and 54 lux). Operate luminaires with a series circuit distribution system at a potential not exceeding 2400 volts.

Control lights and luminaires by photocell controls. For current less than or equal to 10 amperes, furnish a photocell switch. For current greater than 10 amperes, furnish a photocell switch operating a magnetic relay for switching the lighting circuit.

636.07 Traffic Counter. Locate and install traffic counters as shown in the plans.

Mount and orient the cabinet to provide an unobstructed, direct line of sight to the roadways that contain count station and vehicle detection equipment when cabinet door is opened. Install traffic counter and communications devices inside cabinet.

Identify and label loop wires inside each pull box in which the loop wires enter. Maintain consistent wiring identification and labeling when entering the cabinet and with connection to the traffic counter. Use water resistant material for wiring identification and labeling. Obtain approval for loop wire assignments at all locations.

Before powering-on equipment within the cabinet provide a copy of the following:

(a) Voltages for power supplies to include, but not limited to electrical meter, solar panel, batteries, and communications devices, and

(b) Telephone number and/or IP address for all communication devices.

636.08 Traffic Loop. Do not install loops when the pavement is wet. Saw cut, wire, and seal for loop wires on the same day. Do not allow vehicular traffic to pass over an open saw cut unless protected.

Saw clean, smooth, well-defined, $^{5}/_{16}$-inch (8-millimeter) wide and 1¾-inch (45-millimeter) deep cuts without damaging the adjacent pavement. Overlap saw cuts to provide full depth at corners. Saw cut the lead-in to the pull box as close as possible to the edge of pavement. Thoroughly clean the saw cut of foreign material by sandblasting, waterblasting, or mechanical wire brushing. Repeat the process until a new, clean concrete face is exposed. Dry the joint with compressed air.

Install the loop wire in one continuous length at the bottom of the cut. Install without kinks, curls, or other damage to the wire or its insulation. Replace damaged wires. Hold the loop wire in place with 24-inch (600-millimeter) long backer rods.

Where the loop wire crosses a crack or joint, use a plastic sleeve that extends 4 inches (100 millimeters) on each side of the crack or joint. Provide extra loop wire in the sleeve for joint expansion and contraction.

Twist the loop lead-in wires 5 turns per foot (16.5 turns per meter) from the loop to the pull box. Color code the wires of each loop for identification of separate loops. Coil 36 inches (900 millimeters) of lead-in pair slack in the pull box for each loop.

Before applying sealant, test the loop and lead-in for continuity and resistance by applying a 1000-volt megohmmeter between each end of the loop lead-in and the nearest reliable electrical ground. If no available ground exists, establish a ground for the measurement. Record the location and megohmmeter readings and submit readings and test equipment data. Replace the loop if the megohmmeter reading is less than 10 megohms or the inductance is less than 60 microhenries or more than 100 microhenries.

Apply sealant to the saw cuts with the backer rods in place. Apply the sealant in a manner that does not produce air bubbles. Remove excess sealant and finish level with the pavement. Follow the manufacturer's instructions for sufficient time for the sealant to harden before allowing traffic to cross the loops.

Repeat the resistance and continuity test after sealant is applied. Report the second test for comparison with the first test report.

636.09 Testing and Demonstration Period. Before energizing portions of the system, demonstrate that the conductor system is clear and free of short circuits, open circuits, and unintentional grounds. Repair or replace faulty circuits.

After energizing the system, demonstrate that all electrical components work properly. Repair or replace faulty electrical components.

After completing electrical component tests, conduct a demonstration test for 30 continuous days. Adjust and correct deficiencies in the system during the 30-day demonstration period. If part of the system is replaced or repaired, retest that part of the system for an additional 30 days.

636.10 Warranties, Guarantees, and Instruction Sheets. When installations are permanent, deliver manufacturer's warranties, guarantees, instruction sheets, and parts lists at the final inspection.

636.11 Relocations. Use material equivalent to existing material, unless present codes require different or improved material. Existing material may be salvaged and reused, provided material and installation methods used meet the requirements of applicable codes and ordinances.

636.12 Acceptance. Material for traffic signal, traffic counter, lighting and electrical systems will be evaluated under Subsections 106.02 and 106.03.

Installation of traffic signal, traffic counter, lighting and electrical systems will be evaluated under Subsections 106.02 and 106.04.

Structural excavation and backfill will be evaluated under Section 209.

Concrete will be evaluated under Section 601.

Measurement

636.13 Measure the Section 636 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

For relocations, do not measure additional line or connections necessary to place the fixture at the new location.

Payment

636.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 636 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for lump sum pay items will be prorated based on the total work completed.

Section 637. — FACILITIES AND SERVICES

Description

637.01 This work consists of furnishing, installing, maintaining, and removing facilities and services.

Construction Requirements

637.02 General. Provide the facilities and services beginning 14 days before project work begins and ending 21 days after final acceptance.

Facilities and services are for the exclusive use of Government personnel and are subject to approval.

Conform to applicable ordinances, safety codes, and regulations.

If facilities or services become defective, are stolen, or for other reasons do not function as intended; repair or provide a replacement. Repair or replace facilities and services within 8 hours after being notified by the CO. Repairs and replacements are subject to approval.

Remove facilities and services when directed by the CO.

637.03 Facilities. Perform site work to accommodate facilities and restore to its original condition upon removal. Furnish safe, sanitary, weatherproof buildings or trailers in good condition. Suitable commercial or private facilities located near the project may be provided.

(a) Field office. Furnish and maintain a field office according to Tables 637-1 and 637-2.

(b) Residential housing. Furnish and maintain residential housing according to Tables 637-1 and 637-2. When the unit is part of a larger building, separate units with partitions and furnish separate outside doors with locks.

Table 637-1
Minimum Requirements for Field Facilities and Associated Services

Property	Field Office	Residential Housing
Floor space, square feet (square meter)	400 (37)	500 (46)
Locking outside door, deadbolt with keys	1	1
Steps with slip-proof tread and handrails	(1)	(1)
Windows with locks	2	3
Total window area, square feet (square meter)	30 (2.8)	60 (5.6)
Ceiling height, 7 feet (2.1 meters)	✓	✓
Rooms including toilet room	4	5(2)
Room size, except toilet room, square feet (square meter)	100 (9)	100 (9)
Closet, 45-cubic foot (1.2 cubic meter)		2
Shelves, 12-inch (300-millimeter) depth, square feet (square meter)	12 (1.1)	12 (1.1)
Electrical lighting	✓	✓
Heat and air conditioning, maintain temperature of 72±7 °F (22±4 °C)	✓	✓
Adequate electrical outlets	✓	✓
Surge protectors	✓	✓
Adequate electricity (120 and 240 V, 60 cycle as applicable)	✓	✓
Adequate potable water supply	✓	✓
Drinking water cooler with water supply	✓	
Sink with faucets for both hot and cold water		✓
Adequate hot and cold water supply		✓
Shower/bath facilities		✓
Parking for three vehicles on gravel surface	✓	✓
6-foot (1.8 millimeter) high chain link fence with gate around building and parking area	✓	✓

(1) As required by local code.
(2) Includes two bedrooms.

Table 637-2
Minimum Facility Furnishings

Property	Field Office	Residential Housing
Table, 30-inch wide × 8-foot long × 30-inch high (750 mm wide × 2.4 m long × 750 mm high)	1	
File cabinet, 2-drawer, fire resistant, metal, with lock and keys	1	
File cabinet, 4-drawer, metal	1	
Desk, 12-square foot (1.1 square meter)(1)	2	
Desk lamp(1)	2	
Office chair(1)	5	
Storage cabinet, 6-feet wide × 36-inch wide × 18-inch high (1.8 m wide × 900 mm wide × 450 mm high)	1	
Fire extinguisher	1	2
Refrigerator, 10-cubic foot (0.28 cubic meter)		1
Range and oven, standard 36-inch (900-millimeter)		1
Microwave oven, 1.1 cubic foot (0.031 cubic meter), 1100 watt		1
Kitchen table with 4 chairs		1 set
Sofa, 6-foot (1.8-meter)		1
Coffee table		1
Recliner chair		2
End table		3
Table lamp		3
Queen bed		2
Night stand		4
Night stand lamp		4
Dresser, four-drawer, 36-inch (900-millimeter)		2

(1) Meet accepted industry standards for ergonomics.

637.04 Services.

(a) Facilities. Furnish electrical service, potable water supply, toilet accommodations and waste disposal services. Remove snow and provide landscaping services as directed by the CO. Pay bills associated with facilities by the payment due date.

(b) Communications. Provide internet, wireless phone, or landline telephone services of the latest available technology. Pay bills from the service provider by the payment due date. The Government will pay the cost of long distance telephone calls.

637.05 Acceptance. Facilities and services will be evaluated under Subsections 106.02 and 106.04.

Measurement

637.06 Measure the Section 637 pay items listed in the bid schedule according to Subsection 109.02.

Payment

637.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 637 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for facilities and services will be paid as follows:

(a) 60 percent of the pay item amount will be paid upon installation and acceptance for occupancy.

(b) Payment of the remaining 40 percent of the pay item amount will be paid after final acceptance or when the CO orders the removal of the facilities and services.

DIVISION 700
MATERIAL

Section 701. — CEMENT

701.01 Hydraulic Cement. Do not mix cement brands or types.

(a) Portland cement. Conform to AASHTO M 85.

(b) Blended hydraulic cement. Conform to AASHTO M 240.

701.02 Masonry and Mortar Cement.

(a) Masonry cement. Conform to ASTM C91, Type N, Type S, or Type M.

(b) Mortar cement. Conform to ASTM C1329, Type N, Type S, or Type M.

Section 702. — ASPHALT MATERIAL

702.01 Asphalt Binder. Conform to AASHTO M 226 or AASHTO M320.

702.02 Emulsified Asphalt. Conform to AASHTO M 140 or AASHTO M 208.

(a) Polymer modified cationic emulsified asphalt for chip seals. Use a solid or latex polymer added either to the asphalt binder or during the emulsification process. Conform to AASHTO M 316, except as follows:

(1) Force ratio, f_2/f_1, 39.2 °F (4 °C), 5 cm/min, AASHTO T 300	0.3 min.
(2) Elastic recovery, 77 °F (25 °C), 5 cm/min, AASHTO T 301	50 % min.
(3) CRS-2P, penetration, 77 °F (25 °C), 100 g, 5 sec, AASHTO T 49	90 to 150
(4) CRS-2hP, penetration, 77 °F (25 °C), 100 g, 5 sec, AASHTO T 49	50 to 90

(b) Polymer-modified emulsified asphalt for micro-surfacing. Conform to ISSA A143, except use Section 6, *Emulsified Asphalt Residue by Evaporation* of AASHTO T 59 to determine percent residue.

(c) Penetrating emulsified asphalt for prime coat. Conform AASHTO T 59, except as modified by Table 702-1.

Table 702-1
Penetrating Emulsion for Prime Coat

	Minimum	**Maximum**
Requirements for Emulsion		
Viscosity, Saybolt Furol at 122 °F (50 °C), sec	15	150
Settlement, 24-hours, %	–	1
Residue by evaporation, %	62	–
Requirements for Residue		
Penetration, 77 °F (25 °C), 100 g, 5 sec, AASHTO T 49	40	200
Solubility in trichloroethylene, %, AASHTO T 44	97.5	–

702.03 Material for Dampproofing and Waterproofing Concrete and Masonry Surfaces.

(a) Primer. Conform to ASTM D41 for asphalt membranes. Furnish a neoprene-based primer for use with rubberized asphalt membrane. Furnish a resin- or solvent-based primer for use with the modified bitumen membrane.

If preformed membrane sheets are used, furnish primers of a type recommended by the manufacturer.

(b) Asphalt. For mop coat, conform to ASTM D449, Type I or Type II.

(c) Waterproofing fabric. Furnish asphalt saturated fabric conforming to ASTM D173.

If preformed membrane sheet is used, furnish either the rubberized asphalt type or the modified bitumen type. The rubberized asphalt type consists of a rubberized asphalt sheet reinforced with a polyethylene film or mesh. The modified bitumen sheet type consists of a polymer modified bitumen sheet reinforced with a stitch-bonded polyester fabric or fiberglass mesh. Conform to Table 702-2 or 702-3.

Table 702-2
Preformed Membrane Sheet for Surfaces Other Than Bridge Decks

Property	Test	Value	
		Rubberized Asphalt Type	Modified Bitumen Type
Tensile strength in machine direction	ASTM D882	20 lb/in (3.5 kN/m)	20 lb/in (3.5 kN/m)
Elongation at break in machine direction	ASTM D882	150% at 73.4 °F (23 °C)	25% at 73.4 °F (23 °C)
Pliability	ASTM D146(1)	No cracks	No cracks
Thickness, minimum	–	60 mil (1.52 mm)	60 mil (1.52 mm)
Softening point, minimum	ASTM D36(1)	165 °F (74 °C)	210 °F (99 °C)

(1) Base ASTM D146 on a 180-degree bend over a 4.0-inch (100-mm) mandrel at 10 °F (-12 °C).

Table 702-3
Preformed Membrane Sheet for Bridge Decks

Property	Test	Value	
		Rubberized Asphalt Type	Modified Bitumen Type
Tensile strength in machine direction	ASTM D882	50 lb/in (8.75 kN/m)	40 lb/in (7.0 kN/m)
Elongation at break in machine direction	ASTM D882	15% at 73.4 °F (23 °C)	10% at 73.4 °F (23 °C)
Pliability	ASTM D146(1)	No cracks	No cracks
Thickness, minimum	–	65 mils (1.65 mm)	70 mils (1.65 mm)
Softening point, minimum	ASTM D36(1)	165 °F (74 °C)	210 °F (99 °C)

(1) Base ASTM D146 on a 180-degree bend over a 4.0-inch (100-mm) mandrel at 10 °F (-12 °C).

(d) Mastic. Furnish mastic consisting of a rubberized asphalt cold-applied joint sealant for use with preformed rubberized sheets. Furnish mastic consisting of a blend of bituminous and synthetic resins for use with modified bitumen sheet.

(e) Asphalt roll roofing. Conform to ASTM D6380, Class M, Type II.

702.04 Asphalt Mastic. Conform to AASHTO M 243.

702.05 Antistrip Additive. Conform to the following:

(a) Type 1. Furnish commercially produced, heat stable liquid products that when added to an asphalt have the chemical and physical properties to prevent separation of the asphalt from aggregates.

(b) Type 2. Furnish cement conforming to Subsection 701.01 or fly ash conforming to Subsection 725.04(a).

(c) Type 3. Furnish lime conforming to AASHTO M 303.

702.06 Mineral Fiber. Conform to the following:

(a) Fiber length ¼-in (6-mm) max. mean test value

The fiber length is determined according to the Bauer McNett fractionation.

(b) Fiber thickness 0.0002-in (5-µm) max. mean test value

The fiber diameter is determined by measuring at least 200 fibers in a phase contrast microscope.

(c) Shot content Table 702-4

Table 702-4
Mineral Fiber Shot Content(1)

Sieve Size	Nominal Maximum Size Percent Passing
No. 60 (250 µm)	90±5
No. 230 (63 µm)	70±10

(1) Shot content is a measure of non-fibrous material. The shot content is determined on vibrating sieves. See ASTM C612 for additional information.

Section 703. — AGGREGATE

703.01 Fine Aggregate for Concrete. Furnish sand conforming to AASHTO M 6, Class B, except as amended or supplemented by the following:

(a) Material passing No. 200 (75-µm) sieve, AASHTO T 11	3.0 percent max.
(b) Alkali-silica reactivity. Test the aggregate for alkali silica reaction and conform to one of the following (1) through (5):	
(1) Alkali-silica reactivity, ASTM C1260	≤ 0.10 percent at 16 days after casting
(2) Alkali-silica reactivity, ASTM C1260	0.11 percent to 0.20 percent at 16 days after casting
And one of the following examinations:	
(a) Petrographic examination of aggregates, ASTM C295, performed within 1 year from time of submittal	Favorable report for use
(b) Petrographic examination of hardened concrete, ASTM C856, performed on ASTM C1260 specimens after test	Favorable report for use
(3) Alkali-silica reactivity with cementitious material, ASTM C1567, performed on approved mix design mass percent combinations. Do not use lithium compounds as mitigation measures	≤ 0.10 percent at 16 days after casting
(4) Alkali silica reaction, ASTM C1293	< 0.04 percent at 12 months
(5) Alkali-silica reaction with cementitious material, ASTM C1293, performed on approved mix design mass percent combinations	< 0.04 percent at 24 months

For lightweight fine aggregate, conform to AASHTO M 195.

703.02 Coarse Aggregate for Concrete. Conform to AASHTO M 80, Class A, except as amended or supplemented by the following:

(a) Los Angeles abrasion, AASHTO T 96	40 percent max.
(b) Grading, AASHTO M 43	All sizes, except Size Numbers 8, 89, 9, or 10
(c) Alkali-silica reactivity	See Subsection 703.01(b)

For bridge decks or surface courses, do not use aggregates known to polish or carbonate aggregates containing less than 25 percent by mass of insoluble residue as determined by ASTM D3042.

For lightweight coarse aggregate, conform to AASHTO M 195.

703.03 Granular Backfill. Furnish aggregate for the following installations.

(a) Underdrain pipe with geotextile. Furnish granular backfill conforming to AASHTO M 80, Class E and AASHTO M 43, Size Number 3, 4, 5, 57, 67, or 7.

(b) Underdrain pipe without geotextile. Furnish granular backfill conforming to AASHTO M 6, except the soundness test is not required.

703.04 Reserved.

703.05 Subbase, Base, and Surface Course Aggregate.

(a) General. Furnish hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming the following:

(1) Los Angeles abrasion, AASHTO T 96	50 percent max.
(2) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss max.
(3) Durability index (coarse), AASHTO T 210	35 min.
(4) Durability index (fine), AASHTO T 210	35 min.
(5) Fractured faces, ASTM D5821	50 percent min.

(6) Without organic matter and lumps or balls of clay.

(b) Subbase or base aggregate. In addition to Subsection 703.05(a), conform to the following:

(1) Gradation	Table 703-2
(2) Liquid limit, AASHTO T 89	25 max.

Table 703-2
Target Value Ranges for Subbase and Base Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 and T 11)				
	Grading Designation				
	A (Subbase)	B (Subbase)	C (Base)	D (Base)	E (Base)
2½ inch (63 mm)	100(1)				
2 inch (50 mm)	97 – 100(1)	100(1)	100(1)		
1½ inch (37.5 mm)		97 – 100(1)			
1 inch (25 mm)	65 – 79 (6)		80 – 100 (6)	100(1)	
¾ inch (19 mm)			64 – 94 (6)	86 – 100 (6)	100(1)
½ inch (12.5 mm)	45 – 59 (7)				
⅜ inch (9.5 mm)			40 – 69 (6)	51 – 82 (6)	62 – 90 (6)
No. 4 (4.75 mm)	28 – 42 (6)	40 – 60 (8)	31 – 54 (6)	36 – 64 (6)	36 – 74 (6)
No. 40 (425 µm)	9 – 17 (4)			12 – 26 (4)	12 – 26 (4)
No. 200 (75 µm)	4.0 – 8.0 (3)	4.0 – 12.0 (4)	4.0 – 7.0 (3)	4.0 – 7.0 (3)	4.0 – 7.0 (3)

(1) Statistical procedures do not apply.

( ) The value in the parentheses is the allowable deviation (±) from the target values.

(c) Surface course aggregate. In addition to Subsection 703.05(a), conform to the following:

(1) Gradation	Table 703-3
(2) Liquid limit, AASHTO T 89, Method A	35 max.
(3) Plasticity index, AASHTO T 90	10±3

Do not furnish material that contains asbestos fibers.

Table 703-3
Target Value Ranges for Surface Course Gradations

Sieve Size	Percent by Mass Passing Designate Sieve (AASHTO T 27 & AASHTO T 11)
1 inch (25 mm)	100(1)
½ inch (12.5 mm)	70 – 80 (5)
No. 4 (4.75 mm)	40 – 50 (7)
No. 10 (2.0 mm)	25 – 40 (6)
No. 40 (425 µm)	15 – 25 (5)
No. 200 (75 µm)	8.0 – 14.0 (4)

(1) Statistical procedures do not apply.

( ) The value in the parentheses is the allowable deviation (±) from the target values.

703.06 Crushed Aggregate. Furnish hard, durable particles or fragments of crushed stone or gravel conforming to the size and quality requirements for crushed aggregate material normally used locally in the construction and maintenance of highways by Federal or state agencies. Furnish crushed aggregate with a maximum size of 1 inch (25 millimeters) as determined by AASHTO T 27 and AASHTO T 11. Furnish crushed aggregate uniformly graded from coarse to fine and free of organic matter, lumps or balls of clay, and other deleterious material.

703.07 Asphalt Concrete Aggregate. Furnish hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

(a) Los Angeles abrasion, AASHTO T 96	35 percent max.
(b) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles):	
(1) Coarse aggregate	12 percent loss max.
(2) Fine aggregate	12 percent loss max.
(c) Fractured faces, ASTM D5821	90 percent min.
(d) Fine aggregate angularity, AASHTO T 304, Method A	40.0 percent min.
(e) Flat and elongated particles, ASTM D4791 (1:5 ratio, plus ⅜-inch (9.5-mm) sieve, calculated by mass, weighted average)	10 percent max.
(f) Sand equivalent, AASHTO T 176, Alternative Method No. 2, Reference Method	45 min.

(g) Gradation. Size, grade and combine the aggregate fractions in mix proportions that result in a composite blend conforming to the specified gradation. Nominal maximum size is one sieve size greater than the first sieve to retain more than 10 percent of the combined aggregate. Test according to AASHTO T 27 and AASHTO T 11. Volumetric asphalt concrete aggregate gradation. See Table 703-4.

For the surface course, do not use aggregates known to polish or carbonate aggregates containing less than 25 percent by mass of insoluble residue when tested according to ASTM D3042.

Table 703-4
Asphalt Concrete Aggregate Gradation

Sieve Size	Nominal Maximum Aggregate Size – Percent Passing									
	Grading Designation									
	1 inch (25 mm)		¾ inch (19 mm)		½ inch (12.5 mm)		⅜ inch (9.5 mm)		No. 4 (4.75 mm)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
2 inch (50 mm)										
1½ inch (37.5 mm)	100									
1 inch (25 mm)	90	100	100							
¾ inch (19 mm)	*	90	90	100	100					
½ inch (12.5 mm)	*	*	*	90	90	100	100			
⅜ inch (9.5 mm)	*	*	*	*	*	90	90	100	100	
No. 4 (4.75 mm)	*	*	*	*	*	*	*	90	95	100
No. 8 (2.36 mm)	19	45	23	49	28	58	32	67	70	80
No. 16 (1.18 mm)	*	*	*	*	*	*	*	*	*	*
No. 30 (600 µm)	*	*	*	*	*	*	*	*	*	*
No. 50 (300 µm)	*	*	*	*	*	*	*	*	*	*
No. 200 (75 µm)	1.0	7.0	2.0	8.0	2.0	10.0	2.0	10.0	4.0	10.0

***** Contractor specified target values. See Table 703-5 for allowable deviations.

Table 703-5
Allowable Deviation Based on Target Value

Percent by Mass Passing		Allowable Deviation
Minimum	**Maximum**	
70.1	89.9	4
60.1	70.0	5
55.1	60.0	6
45.1	55.0	7
40.1	45.0	6
30.1	40.0	5
21.1	30.0	4
8.1	21.0	3
0	8.0	2

703.08 Open-Graded Asphalt Friction Course Aggregate. Furnish hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

(a) Los Angeles abrasion, AASHTO T 96	35 percent max.
(b) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles), coarse aggregate	12 percent loss max.
(c) Fractured faces, ASTM D5821 (two or more)	75 percent min.
(d) Gradation	Table 703-6

Table 703-6
Target Value Ranges for
Open Graded Friction Course Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)	
	Grading Designation	
	A	**B**
½ inch (12.5 mm)	–	100
⅜ inch (9.5 mm)	100	95 – 100
No. 4 (4.75 mm)*	30 – 45	50 – 70
No. 8 (2.36 mm)*	5 – 15	5 – 15
No. 200 (75 µm)*	2.0 – 5.0	2.0 – 5.0

***** Contractor specified target values. See Table 703-5 for allowable deviations.

703.09 Chip Seal Aggregate. Furnish hard durable particles or fragments of crushed gravel, crushed stone, crushed slag, or lightweight aggregates. Use only one type of aggregate on the surface treatment. Conform to the following:

(a) Gradation	Table 703-7
(b) Clay lumps and friable particles, AASHTO T 112	1.0 percent max.
(c) Flat and elongated particles, ASTM D4791 (1:3 ratio, plus ⅜-inch (9.5-mm) sieve, calculated by mass, weighted average)	10 percent max.
(d) Fractured faces, ASTM D5821	90 percent min.
(e) Los Angeles abrasion, AASHTO T 96	40 percent max.
(f) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss max.

Table 703-7
Target Value Ranges for
Single and Double Course Chip Seal Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & AASHTO T 11)			
	Grading Designation			
	A	B	C	D
1½ inch (37.5 mm)				
1 inch (25 mm)	100 (1)			
¾ inch (19 mm)	90 – 100 (3)	100 (1)		
½ inch (12.5 mm)	0 – 35 (5)	90 – 100 (3)	100 (1)	
⅜ inch (9.5 mm)	0 – 12 (3)	0 – 35 (5)	85 – 100 (3)	100 (1)
No. 4 (4.75 mm)	–	0 – 12 (3)	0 – 35 (5)	85 – 100 (3)
No. 8 (2.36 mm)	–	–	0 – 8 (3)	0 – 23 (4)
No. 200 (75 µm)	0.0 – 1.0 (0.5)	0.0 – 1.0 (0.5)	0.0 – 1.0 (0.5)	0.0 – 1.0 (0.5)

(1) Statistical procedures do not apply.

( ) The value in the parentheses is the allowable deviation (±) from the target values.

703.10 Slurry Seal and Micro Surfacing Aggregate. Furnish hard durable particles or fragments of crushed gravel or crushed stone.

(a) Slurry seal aggregate. Conform to ISSA A105 and the following:

(1) Gradation	Table 703-8
(2) Los Angeles abrasion, AASHTO T 96, Grading D	35 percent max.

(3) Sand equivalent, AASHTO T 176, Alternate Method No. 2, Reference Method — 45 min.

(4) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles) — 15 percent loss max.

(b) Micro surfacing aggregate. Conform to ISSA A143 and the following:

(1) Gradation — Table 703-8

(2) Los Angeles abrasion, AASHTO T 96, Grading D — 30 percent max.

(3) Sand equivalent AASHTO T 176, Alternate Method No. 2, Reference Method — 65 min.

(4) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles) — 15 percent loss max.

Table 703-8
Micro Surfacing and Slurry Seal Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & AASHTO T 11)		
	Grading Designation		
	I	II	III
⅜ inch (9.5 mm)	–	100	100
No. 4 (4.75 mm)	100	90 – 100	70 – 90
No. 8 (2.36 mm)	90 – 100	65 – 90	45 – 70
No. 16 (1.18 mm)	65 – 90	45 – 70	28 – 50
No. 30 (600 µm)	40 – 65	30 – 50	19 – 34
No.50 (300 µm)	25 – 42	18 – 30	12 – 25
No. 100 (150 µm)	15 – 30	10 – 21	7 – 18
No. 200 (75 µm)	10.0 – 20.0	5.0 – 15.0	5.0 – 15.0

703.11 Reserved.

703.12 Blotter. Furnish sound durable particles of gravel or crushed stone conforming to the following:

(a) Material passing ⅜-inch (9.5-mm) sieve, AASHTO T 27 — 100 percent

(b) Liquid limit, AASHTO T 89, Method A — 25 max.

(c) Without organic matter and clay balls.

703.13 Aggregate for Aggregate-Topsoil Course. Conform to AASHTO M 80, Class E and AASHTO M 43, Size Number 57.

703.14 Sand. Furnish clean material conforming to the following:

(a) Gradation	AASHTO M 6
(b) Deleterious material	AASHTO M 6, Class B

703.15 Aggregate for Lean Concrete Backfill. Furnish hard, clean, durable, nonplastic, nonorganic, nonreactive aggregate to meet the designated gradation in Table 703-10.

Table 703-10
Aggregate for Lean Concrete Backfill

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
1 inch (25 mm)	100
No. 200 (75 µm)	0.0 – 10.0

703.16 Shotcrete Aggregate. Combine fine and coarse aggregates to meet the designated gradation in Table 703-11.

Table 703-11
Shotcrete Gradation Limits for Combined Aggregates

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & AASHTO T 11)	
	Grading Designation	
	A	B
½ inch (12.5 mm)	—	100
⅜ inch (9.5 mm)	100	90 – 100
No. 4 (4.75 mm)	95 – 100	70 – 85
No. 8 (2.36 mm)	80 – 98	50 – 70
No. 16 (1.18 mm)	50 – 85	35 – 55
No. 30 (600 µm)	25 – 60	20 – 35
No. 50 (300 µm)	10 – 30	8 – 20
No. 100 (150 µm)	2.0 – 10.0	2.0 – 10.0

(a) Fine aggregate. Conform to AASHTO M 6, Class B, except as amended or supplemented by the following:

(1) Material passing No. 200 (75-µm) sieve, AASHTO T 11	3.0 percent max.
(2) Sand equivalent value, AASHTO T 176, Alternate Method No. 2, Reference Method	75 min.
(3) Alkali-silica reactivity	See Subsection 703.01(b)

(b) Coarse aggregate. Conform to AASHTO M 80, Class A, except as amended or supplemented by the following:

(1) Los Angeles abrasion, AASHTO T 96	40 percent max.

(2) Alkali-silica reactivity — See Subsection 703.01(b)

703.17 Granular Rock Backdrain. Furnish hard, durable rock conforming to the following:

(a) Los Angeles abrasion, AASHTO T 96 — 50 percent max.

(b) Apparent specific gravity, AASHTO T 85 — 2.50 min.

(c) Absorption, AASHTO T 85 — 4.0 percent max.

(d) Durability index (course), AASHTO T 210 — 50 min.

(e) Gradation — Table 703-12

Table 703-12
Granular Rock Backdrain Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & AASHTO T 11)
6 inch (150 mm)	100
4 inch (100 mm)	0 – 25
No. 200 (75µm)	0.0 – 5.0

Section 704. — SOIL

704.01 Foundation Fill. Furnish a suitable material conforming to the following:

(a) Maximum particle size	2 in (50 mm)
(b) Soil classification, AASHTO M 145	A-1-a
(c) Material passing No. 200 (75-µm) sieve, AASHTO T 27 and AASHTO T 11	6.0 percent max.

704.02 Bedding Material. Furnish a suitable, well-graded, free draining material conforming to the following:

(a) Maximum particle size	½ in (12.5 mm) or half the corrugation depth, whichever is smaller
(b) Material passing No. 200 (75-µm) sieve, AASHTO T 27 and AASHTO T 11	10.0 percent max.

704.03 Backfill Material. Furnish a suitable, well-graded, compactable material conforming to the following:

(a) For structures and pipes other than plastic pipe:

(1) Maximum particle size	3 in (75 mm)
(2) Soil classification, AASHTO M 145	A-1, A-2, or A-3

(b) For reinforced soil slopes and plastic pipe:

(1) Maximum particle size	1½ in (37.5 mm)
(2) Soil classification, AASHTO M 145	A-1, A-2-4, A-2-5, or A-3

704.04 Structural Backfill. Furnish a suitable, free draining material conforming to the following:

(a) Maximum particle size	3 in (75 mm)
(b) Material passing No. 200 (75-µm) sieve, AASHTO T 27 and AASHTO T 11	15.0 percent max.
(c) Plasticity index, AASHTO T 90	6 max.

704.05 Topping. Furnish a suitable, granular material conforming to the following:

(a) Maximum particle size	3 in (75 mm)
(b) Soil classification, AASHTO M 145	A-1 or A-2-4

704.06 Unclassified Borrow. Furnish a suitable material conforming to the following:

(a) Maximum particle size	24 in (600 mm)
(b) Soil classification, AASHTO M 145	A-1, A-3, or A-2-4

704.07 Select Borrow. Furnish a suitable, well-graded material conforming to the following:

(a) Gradation	Table 704-1
(b) Liquid limit, AASHTO T 89, Method A	30 max.

Table 704-1
Select Borrow Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & AASHTO T 11)
3 inch (75 mm)	100
1 inch (25 mm)	70 – 100
No. 4 (4.75 mm)	30 – 70
No. 200 (75 µm)	0.0 – 5.0

704.08 Select Granular Backfill. Furnish suitable, sound, durable, granular material conforming to the following:

(a) Quality requirements.

(1) Gradation	Table 704-2
(2) Angle of internal friction on the portion passing the No. 10 (2-mm)sieve, AASHTO T 236	34 degree min.

Note: Compact samples for AASHTO T 236 to 95 percent of the maximum density determined according to AASHTO T 99, Method C or D and corrected for oversized material according to AASHTO T 99, Note 9.

(3) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	15 percent loss max.
(4) Plasticity index, AASHTO T 90	6 max.
(5) Los Angeles abrasion, AASHTO T 96	50 percent max.

Table 704-2
Select Granular Backfill Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & AASHTO T 11)
4 inch (100 mm)	100
No. 40 (425 µm)	0 – 60
No. 200 (75 µm)	0.0 – 15.0

(b) Electrochemical requirements for MSE walls with metallic reinforcements.

(1) Resistivity, AASHTO T 288	3000 Ω centimeter min.
(2) pH, AASHTO T 289	5.0 to 10.0
(3) Sulfate content, AASHTO T 290	200 ppm max.
(4) Chloride content, AASHTO T 291	100 ppm max.

Note: Tests for sulfate and chloride content are not required when resistivity is greater than 5000 ohm centimeters.

(c) Electrochemical requirements for MSE walls with geosynthetic reinforcements.

pH, AASHTO T 289	5.0 to 10.0

Section 705. — ROCK

705.01 Gabion and Revet Mattress Rock. Furnish angular stone from a rock quarry or cut that is hard, durable, free of organic and spoil material, and resistant to weathering and water action. Do not use crushed river rock or rock with rounded surfaces. Conform to the following:

(a) Durability index (course), AASHTO T 210	50 min.
(b) Density of a filled basket	100 lb/ft^3 (1600 kg/m^3) min.

(c) Gradation. Furnish rock with breadth and thickness at least one-third its length.

(1) Baskets 1 foot (300 millimeters) or greater in the vertical dimension.

(a) Maximum dimension	8 in (200 mm)
(b) Minimum dimension	4 in (100 mm)

(2) Baskets less than 1 foot (300 millimeters) in the vertical dimension.

(a) Maximum dimension	6 in (150 mm)
(b) Minimum dimension	3 in (75 mm)
(d) Los Angeles abrasion, AASHTO T 96	50 percent max.

705.02 Riprap. Furnish hard, durable, angular rock that is resistant to weathering and water action and free of organic or other unsuitable material. Angular rock is characterized by sharp, clean edges at the intersections of relatively flat surfaces. Do not use shale, rock with shale seams, or other fissile or fissured rock that may break into smaller pieces in the process of handling and placing. Conform to the following:

(a) Apparent specific gravity, AASHTO T 85	2.40 min.
(b) Absorption, AASHTO T 85	4.0 percent max.
(c) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss max.
(d) Los Angeles abrasion, AASHTO T 96	50 percent max.
(e) Rock particle intermediate dimension (width) and minimum dimension (thickness)	⅓ longest dimension (length) min.
(f) Gradation, FLH T 521	Table 705-1

Table 705-1
Gradation Requirements for Riprap[1]

Class	% of Rock Equal or Smaller by Count, D_X	Range of Intermediate Dimensions,[2] inches (millimeters)	Range of Rock Mass,[3] pounds (kilograms)
1	100	9 – 15 (230 – 380)	59 – 270 (27 – 120)
	85	7 – 11 (180 – 280)	28 – 110 (13 – 50)
	50	5 – 8 (130 – 200)	10 – 42 (5 – 19)
	15	3 – 6 (80 – 150)	2 – 18 (1 – 8)
2	100	15 – 21 (380 – 530)	270 – 750 (120 – 340)
	85	11 – 15 (280 – 380)	110 – 270 (50 – 120)
	50	8 – 11 (200 – 280)	42 – 110 (19 – 50)
	15	6 – 8 (130 – 200)	10 – 42 (6 – 19)
3	100	21 – 27 (530 – 690)	750 – 1600 (340 – 730)
	85	15 – 19 (380 – 480)	270 – 560 (120 – 250)
	50	11 – 14 (280 – 360)	110 – 220 (50 – 100)
	15	8 – 10 (200 – 250)	42 – 81 (19 – 37)
4	100	27 – 33 (690 – 840)	1600 – 2900 (730 – 1300)
	85	19 – 23 (480 – 580)	560 – 990 (250 – 450)
	50	14 – 17 (360 – 430)	220 – 400 (100 – 180)
	15	9 – 12 (230 – 300)	59 – 140 (27 – 64)
5	100	33 – 39 (840 – 990)	2900 – 4850 (1300 – 2200)
	85	23 – 28 (580 – 710)	990 – 1800 (450 – 820)
	50	17 – 20 (430 – 510)	400 – 650 (180 – 290)
	15	11 – 15 (280 – 380)	110 – 270 (50 – 120)
6	100	39 – 45 (990 – 1140)	4850 – 7400 (2200 – 3350)
	85	28 – 32 (710 – 810)	1800 – 2650 (820 – 1200)
	50	20 – 23 (510 – 580)	650 – 990 (290 – 450)
	15	13 – 17 (330 – 430)	180 – 400 (82 – 180)
7	100	45 – 54 (1140 – 1370)	7400 – 12,800 (3350 – 5800)
	85	32 – 38 (810 – 970)	2650 – 4450 (1200 – 2000)
	50	23 – 28 (580 – 710)	990 – 1800 (450 – 820)
	15	15 – 20 (380 – 510)	270 – 650 (120 – 290)
8	100	54 – 66 (1370 – 1680)	12,800 – 23,400 (5800 – 10,600)
	85	38 – 47 (970 – 1190)	4450 – 8450 (2000 – 3850)
	50	28 – 35 (710 – 890)	1800 – 3500 (820 – 1600)
	15	19 – 25 (480 – 640)	560 – 250 (250 – 570)
9	100	66 – 78 (1680 – 1980)	23,400 – 38,600 (10,600 – 17,500)
	85	47 – 55 (1190 – 1400)	8450 – 13,500 (3850 – 6100)
	50	35 – 41 (890 – 1040)	3500 – 5600 (1600 – 2550)
	15	22 – 30 (560 – 760)	870 – 2200 (390 – 1000)
10	100	78 – 90 (1980 – 2290)	38,600 – 59,300 (17,500 – 26,900)
	85	55 – 64 (1400 – 1630)	13,500 – 21,300 (6100 – 9650)
	50	41 – 48 (1040 – 1220)	5600 – 9000 (2550 – 4100)
	15	26 – 36 (660 – 910)	1450 – 3800 (660 – 1700)

(1) Gradation includes spalls and rock fragments to provide a stable, dense mass.

(2) The intermediate dimension is the longest straight-line distance across the rock that is perpendicular to the rock's longest axis on the rock face with the largest projection plane.

(3) Rock mass is based on a specific gravity of 2.65 and 85 percent of the cubic volume as calculated using the intermediate dimension.

705.03 Rock for Masonry Structures. Conform to the size and shape specified. Furnish sound, durable rock of the texture and color specified and has been proven satisfactory for the intended use. Do not furnish rock containing reeds, rifts, seams, laminations, and minerals that may cause discoloration or deterioration from weathering.

705.04 Rock for Special Rock Embankment. Furnish angular stone that is hard, durable, resistant to abrasion and weathering, and that is free of weak cleavages that may cause the rock to disintegrate during handling and placing.

(a) Mechanically-placed embankments. Furnish rock conforming to Table 705-2.

Table 705-2
Range of Mechanically-Placed Rock

Percent of Rock Fragments by Mass	Range of Intermediate Dimensions,(1) inches (millimeters)	Range of Rock Mass,(2) pounds (kilograms)
50	> 29 (725)	> 2000 (900)
50	10 – 29 (250 – 725)	90 – 2000 (40 – 900)

(1) The intermediate dimension is the longest straight-line distance across the rock that is perpendicular to the rock's longest axis on the rock face with the largest projection plane.
(2) Rock mass is based on a specific gravity of 2.65.

(b) Hand-placed embankments. Furnish rock conforming to Table 705-3.

Table 705-3
Range of Hand-Placed Rock

Percent of Rock Fragments by Mass	Range of Intermediate Dimensions,(1) inches (millimeters)	Range of Rock Mass,(2) pounds (kilograms)
75	> 14 (350)	> 165 (75)
25	10 – 14 (250 – 350)	90 – 165 (40 – 75)

(1) The intermediate dimension is the longest straight-line distance across the rock that is perpendicular to the rock's longest axis on the rock face with the largest projection plane.
(2) Rock mass is based on a specific gravity of 2.65.

705.05 Rock for Buttresses.

(a) General. Furnish angular stone that is hard, durable, free of organic and spoil material, and resistant to weathering and water action. Conform to the following:

(1) Rock breadth and thickness	At least one-third of the rock length
(2) Apparent specific gravity, AASHTO T 85	2.40 min.
(3) Absorption, AASHTO T 85	4.0 percent max.
(4) Durability index (course), AASHTO T 210	52 min.

(b) Mechanically-placed buttresses. In addition to Subsection 705.05(a), furnish rock conforming to Table 705-2.

(c) Hand-placed buttresses. In addition to Subsection 705.05(a), furnish rock conforming to Table 705-3.

705.06 Rock for Rockeries. Furnish hard, angular, and durable rock that consists of a solid mass without open fractures, foliation, or other planes of weakness that are generally cubical, tabular, or rectangular in shape. Do not furnish crushed river rock or rock with rounded surfaces. Conform to the following:

(a) Apparent specific gravity, AASHTO T 85	2.40 min.
(b) Absorption, AASHTO T 85	4.0 percent max.
(c) Los Angeles abrasion, AASHTO T 96	50 percent max.
(d) Durability index (course), AASHTO T 210	52 min.
(e) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss max.
(f) Size and shape.	
(1) Rock length	See plans
(2) Rock breadth and thickness	At least one-third of rock length
(3) Rock dimension	18 in (460 mm) min.
(4) Cap rock mass	200 lb (90 kg) min.

705.07 Rock Mulch. Furnish hard, durable native rock that is resistant to weathering and free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Maximum particle size	6 in (150 mm)
(b) Minimum particle size	2 in (50 mm)
(c) Apparent specific gravity, AASHTO T 85	2.40 min.
(d) Absorption, AASHTO T 85	4.0 percent max.
(e) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss max.
(f) Los Angeles abrasion, AASHTO T 96	50 percent max.

Section 706. — CONCRETE PIPE

706.01 Non-Reinforced Concrete Pipe. Conform to AASHTO M 86 for the diameters and strength classes specified.

706.02 Reinforced Concrete Pipe. Conform to AASHTO M 170 for the diameters and strength classes specified. For precast reinforced concrete end sections, conform to cited specifications to the extent they apply.

706.03 Perforated Concrete Pipe. Conform to AASHTO M 175, Type 1 or Type 2 and AASHTO M 86 for the diameters and strength classes specified.

706.04 Reinforced Arch-Shaped Concrete Pipe. Conform to AASHTO M 206 for the diameters and strength classes specified.

706.05 Reinforced Elliptically-Shaped Concrete Pipe. Conform to AASHTO M 207 for the diameters, placement design (horizontal or vertical), and strength classes specified.

706.06 Reinforced D-Load Concrete Pipe. Conform to AASHTO M 242 for the diameters specified.

706.07 Precast Reinforced Concrete Box Sections. Conform to ASTM C1577. Meet the design requirements for AASHTO, *Load and Resistance Factor Design (LRFD) Bridge Design Specifications* with HL-93 live loading. Clearly mark the following information on the inner surface of each box section by indentation, waterproof paint or other approved means:

(a) Box span and rise;

(b) Date of manufacture;

(c) Name of manufacturer;

(d) Submittal number; and

(e) Date certified by manufacturer.

706.08 Gaskets for Concrete Pipe.

(a) Elastomeric seals. Conform to ASTM C1619, Class C.

(b) Resilient connectors. Conform to ASTM C923.

706.09 Supplemental Concrete Pipe Ties. Conform to ASTM A307 and galvanize tie hardware.

Section 707. — METAL PIPE

707.01 Ductile Iron Culvert Pipe. Conform to ASTM A716 for the sizes specified.

707.02 Metallic-Coated Corrugated Steel Pipe. Furnish pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections) and coupling bands conforming to AASHTO M 36 and either AASHTO M 218, AASHTO M 274, or AASHTO M 289 for the dimensions and thicknesses specified.

Fabricate underdrain pipe from steel sheets with a minimum thickness of 0.052 inches (1.32 millimeters). Use any class of perforation specified in AASHTO M 36.

707.03 Aluminum-Alloy Corrugated Pipe. Furnish pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections) and coupling bands conforming to AASHTO M 196 for the dimensions and thicknesses specified.

Fabricate underdrain pipe from aluminum sheets with a minimum thickness of 0.048 inches (1.22 millimeters). Use any class of perforation.

707.04 Asphalt-Coated Pipe. Furnish pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections), and coupling bands conforming to Section 707 as applicable for the kinds of pipes to be coated.

Coat the pipe with asphalt material conforming to AASHTO M 190 for the type of coating specified. Coat special sections (such as elbows, branch connections, and end sections) and coupling bands according to AASHTO M 190. Coat flared end sections with an asphalt coating conforming to AASHTO M 190, Type A or a field applied asphalt mastic coating conforming to AASHTO M 243.

707.05 Steel Structural Plate Structures. Furnish structures and assembly fasteners for connecting plates conforming to AASHTO M 167 for the sizes and types specified.

707.06 Aluminum-Alloy Structural Plate Structures. Furnish structures and assembly fasteners for connecting plates conforming to AASHTO M 219 for the sizes and types specified.

707.07 Asphalt-Coated Structural Plate Structures. Furnish structures conforming to either Subsection 707.05 or 707.06 as applicable. Coat with an asphalt coating conforming to AASHTO M 190, Type A or a field applied asphalt mastic coating conforming to AASHTO M 243.

If the asphalt coating is applied to the plates before field erection, identify each plate's nominal metal thickness by painting the data on the inside surface of the plates after coating. Other methods of plate identification may be used if approved.

707.08 Polymer-Coated Steel Pipe. Furnish pipe, special sections (such as elbows and branch connections) and coupling bands conforming to AASHTO M 245, Grade 250/250 and AASHTO M 246, Grade 250/250.

707.09 Reserved.

707.10 Slotted Drain Pipe. Furnish pipe conforming to AASHTO M 36 and either AASHTO M 218, AASHTO M 274, or AASHTO M 289 for the dimensions and thicknesses specified.

Fabricate the pipe with either angle slots or grate slots and as shown in the plans.

Furnish grate assemblies for the grate slot drain conforming to ASTM A1011, SS Grade 36. Galvanize slot angles and grate slot assemblies according to Subsection 725.10.

707.11 Metallic-Coated Spiral Rib Pipe. Furnish pipe, special sections (such as elbows and branch connections), and coupling bands conforming to AASHTO M 36, Type IR and Type IIR, AASHTO M 218, AASHTO M 274, or AASHTO M 289 for the dimensions and thicknesses specified.

707.12 Aluminum-Alloy Spiral Rib Pipe. Furnish pipe, special sections (such as elbows and branch connections) and coupling bands conforming to AASHTO M 196, Type IR and Type IIR for the dimensions and thicknesses specified.

707.13 Concrete-Lined Corrugated Steel Pipe. Furnish pipe, special sections (such as elbows and branch connections), and coupling bands conforming to Subsection 707.02 for the dimensions and thicknesses specified. Fully line the pipe and special sections with concrete according to ASTM A849, Class C.

707.14 Invert-Paved Corrugated Steel Pipe. Furnish pipe, special sections (such as elbows and branch connections), and coupling bands conforming to Subsection 707.02 for the dimensions and thicknesses specified. Pave the invert of the pipe and special sections with concrete or asphalt material according to ASTM A849, Class A or Class C.

707.15 Cast Iron Soil Pipe and Fittings. Conform to ASTM A74, Class SV for the designated sizes.

707.16 Seamless Copper Water Tube and Fittings. Conform to ASTM B88, Type L for the designated sizes.

707.17 Gaskets for Metal Pipe.

(a) O-ring gaskets for flexible metal pipe. Conform to ASTM C1619, Class C.

(b) Continuous flat gaskets for flexible metal pipe with flat bands or bands with projections.

(1) Conform to ASTM D1056.

(2) Gasket thickness — ½ in (13 mm) greater than the nominal depth of pipe corrugations

(c) Continuous flat gaskets for flexible metal pipe with corrugated bands.

(1) Conform to ASTM D1056.

(2) Gasket thickness — ⅜ in (10 mm)

707.18 Gaskets for Ductile Iron Pipe. Conform to ASTM A746.

Section 708. — PLASTIC PIPE

708.01 Smooth Wall Polyethylene Pipe. Furnish perforated and nonperforated 12- to 42-inch (300- to 1050-millimeter) diameter pipe conforming to ASTM F714 and minimum cell Class PE335434C according to ASTM D3350.

708.02 Corrugated Polyethylene Pipe.

(a) General use. Furnish perforated and nonperforated 12- to 36-inch (300- to 900-millimeter) diameter pipe conforming to AASHTO M 294.

(b) Sanitary sewers. Furnish AASHTO M 294, Type S pipe.

(c) Water systems (4-inches (100 millimeters) and over). Furnish pipe conforming to the requirements of ANSI/AWWA C906. Fabricate from high-density polyethylene PE3408 conforming to a minimum cell Class 345464 C, D or E according to ASTM D3350.

708.03 Profile Wall (Ribbed) Polyethylene Pipe. Furnish perforated and nonperforated 18- to 48-inch (450- to 1200-millimeter) diameter pipe conforming to ASTM F894 and minimum cell Class 334433C or 335434C according to ASTM D3350.

708.04 Corrugated Polyethylene Drainage Tubing. Furnish perforated and nonperforated 3- to 10-inch (75- to 250-millimeter) diameter tubing conforming to AASHTO M 252.

708.05 Smooth Wall Polyvinyl Chloride (PVC) Pipe.

(a) General use. Furnish perforated and nonperforated 4- to 15-inch (100- to 375-millimeter) diameter pipe conforming to AASHTO M 278 and minimum cell Class 12454 or Class 12364 according to ASTM D1784.

(b) Sanitary sewers. Conform to ASTM D3034.

(c) Water systems.

(1) PVC pipe (4-inches (100 millimeters) and over). Furnish pipe and fittings conforming to the requirements of ANSI/AWWA C900 or ANSI/AWWA C905, and listed by Underwriters Laboratories, Inc. Furnish joints conforming to the requirements of ASTM D3139 and using a restrained rubber gasket conforming to ASTM F477.

(2) PVC pipe (under 4-inches (100 millimeters)). Furnish pipe and fittings conforming to ASTM D2241. Select PVC 1120, PVC 1220, or PVC 2120 with a minimum wall thickness equal or greater than a standard dimension ratio (SDR) of 21. Furnish pipes bearing the National Sanitation Foundation Seal for use to transport potable water. Furnish joints conforming to the requirements of ASTM D3139 using a restrained rubber gasket conforming to ASTM F477. Furnish solvent cement for pipe and fittings conforming to ASTM D2564.

(d) Horizontal drains. Furnish Schedule 80 pipe conforming to ASTM D1785. Select PVC 1120, PVC 1220, PVC 2112, PVC 2116, or PVC 2120. Furnish Schedule 80, solvent weld fittings conforming to ASTM D2467.

708.06 Profile Wall (Ribbed) Polyvinyl Chloride Pipe. Furnish perforated and nonperforated 4- to 48-inch (100- to 1200-millimeter) diameter pipe conforming to AASHTO M 304 and minimum cell Class 12454C or Class 12364C according to ASTM D1784. For sanitary sewer applications, conform to ASTM F794 or ASTM F949.

708.07 Acrylonitrile-Butadiene-Styrene (ABS) Pipe. Conform to ASTM D2680.

708.08 Gaskets for Plastic Pipe.

(a) Elastomeric seals. Conform to ASTM F477.

(b) Thermoplastic elastomeric seals. Conform to ASTM F913.

Section 709. — REINFORCING STEEL AND WIRE ROPE

709.01 Reinforcing Steel.

(a) General. Furnish the following information with each shipment of steel to the project:

(1) Name and location of the steel rolling mill;

(2) Manufacturing process;

(3) Heat numbers;

(4) Sizes;

(5) Specifications;

(6) Copies of mill test analyses for chemical and physical tests; and

(7) Consignee and destination of shipment.

(b) Reinforcing bars. Furnish deformed, Grade 60 (420) bars conforming to AASHTO M 31 or AASHTO M 322.

(c) Epoxy-coated reinforcing bars. Furnish bars conforming to Subsection 709.01(b). Conform to ASTM A775.

Inspect the reinforcing bars after the near white blast cleaning. Reject bars with steel slivers or scabs. Selective sorting and rejection at the fabricator's shop may avoid unnecessary delays and subsequent rejection of bars during the precoating inspection at the coating applicator's shop.

Coat epoxy-coated reinforcing steel in a plant certified by CRSI as a fusion bonded epoxy applicator.

(d) Tie bars. Furnish deformed, Grade 60 (420) bars conforming to AASHTO M 31.

(e) Hook bolts. Furnish plain, Grade 60 (420) bars conforming to AASHTO M 31 with M14 rolled threads or M16 cut threads. Furnish a threaded sleeve nut capable of sustaining a minimum axial load of 15,000 pounds (67 kilonewtons).

(f) Dowel bars. Conform to AASHTO M 254, Type A or Type B. Use plain round bars, without burring or other deformation restricting free movement in the concrete. Paint half the length of each dowel bar with one coat of tar paint. When the paint dries and immediately before placing the dowels, lubricate the painted end to prevent concrete from bonding to the painted end.

For expansion joints, furnish a dowel cap that snugly covers 2±¼ inches (50±6 millimeters) of the dowel, has a closed end, and has a suitable stop to hold the closed end 1 inch (25 millimeters) from the end of the dowel bar.

Lubricants for Type B dowels may be medium setting emulsified asphalt or a flaked graphite. Lubricants are not required for Type A coated dowel bars.

Furnish dowel assemblies that hold dowel bars within ¼-inch (6-millimeter) tolerance vertically and horizontally during concrete placement and permit unrestricted movement of the pavement slab.

Use wire conforming to AASHTO M 32 for dowel assemblies. Coat dowel assemblies with the same material as the dowel bar. Recoat or repair damaged coatings equivalent to the manufacturer's original coating.

(g) Deformed steel wire. Conform to AASHTO M 225.

(h) Steel welded wire reinforcement, plain, for concrete. Conform to AASHTO M 55.

(i) Cold-drawn steel wire. Conform to AASHTO M 32.

(j) Welded deformed steel wire fabric. Conform to AASHTO M 221.

(k) Fabricated deformed steel bar or rod mats. Conform to AASHTO M 54.

(l) Low alloy steel deformed bars. Conform to ASTM A706.

709.02 Prestressing Steel.

(a) Fabricate from one of the following:

(1) Stress-relieved steel wire, AASHTO M 204, Type BA or Type WA;

(2) Uncoated seven-wire steel strand, AASHTO M 203, Grade 270 (1860); or

(3) High-strength steel bars, AASHTO M 275, Type II

(b) Submit representative samples from prestressed members fabricated off site. In the case of wire or strand, take the sample from the same master roll.

(1) Pretensioning method. Furnish a sample at least 6 feet (1.8 meters) long of each strand size from each coil.

(2) Post-tensioning method. Furnish samples of the following lengths.

(a) For wires requiring a head, 15 feet (5 meters).

(b) For wires not requiring a head, sufficient length to make up one parallel-lay cable 5 feet (1.5 meters) long consisting of the same number of wires as the cable to be furnished.

(c) For strands furnished with fittings, 5 feet (1.5 meters) between near ends of fittings.

(d) For bars to be furnished with threaded ends and nuts, 5 feet (1.5 meters) between threads at ends.

Section 710. — FENCE AND GUARDRAIL

710.01 Barbed Wire. Furnish galvanized wire or aluminum coated wire conforming to AASHTO M 280.

710.02 Woven Wire. Furnish galvanized fabric or aluminum coated fabric conforming to AASHTO M 279.

710.03 Chain Link Fence. Furnish fabric, posts, rails, ties, bands, bars, rods and other fittings, and hardware conforming to AASHTO M 181.

Furnish 0.177-inch (4.5-millimeter) coiled spring steel tension wire conforming to ASTM A641 hard temper with a Class 3 galvanized coating. Use the same coating on the tension wire as used on the rest of the chain link fence.

710.04 Fence Posts and Bollards.

(a) Wood. Conform to AASHTO M 168.

Peel bark, except for red cedar posts and bracing, which do not require peeling. Trim knots flush with the surface and season the wood.

For dimension lumber for fences, bollards, or gates, use timber that is sound, straight, and reasonably without knots, splits, and shakes. Provide S4S finish.

(b) Concrete. Conform to Section 601.

(c) Steel. For line fence posts, conform to AASHTO M 281. For chain link fence, conform to AASHTO M 181.

710.05 Fence Gates. For frame gates using chain link fabric, conform to AASHTO M 181. Use the same chain link fabric in the gate as in the fence.

710.06 Rail Elements.

(a) Metal beam rail. Furnish metal beam rail conforming to AASHTO-AGC-ARTBA, *A Guide to Standardized Highway Barrier Hardware*.

(1) Galvanized steel. Furnish W-beam or thrie beam rail fabricated from corrugated sheet steel conforming to AASHTO M 180 for the designated shape, class, type, and mass of coating specified;

(2) Painted steel. Furnish W-beam or thrie beam rail conforming to AASHTO M 180 for the designated shape, class, type, and mass of coating specified; or

(3) Corrosion resistant (weathering) steel. Furnish W-beam or thrie beam rail conforming to AASHTO M 180, Type IV, Class B.

(b) Box beam rail. Furnish steel box beam rail conforming to AASHTO-AGC-ARTBA, *A Guide to Standardized Highway Barrier Hardware*.

(c) Steel-backed timber rail. Furnish timber conforming to AASHTO M 168. Fabricate the timber rail from dry, seasoned, and dressed rough sawn Douglas fir, southern pine, or other species having a stress grade of at least 1,500 pounds per square inch (10 megapascals). Do not use refractory species (such as larch or Rocky Mountain Douglas fir). Treat according to AASHTO M 133.

Fabricate steel backing elements according to ASTM A242.

(d) Steel-backed log rail. Use logs that are seasoned, straight, and sound No. 1 Grade Western Hemlock, Western Red Cedar, or Pine. Do not use logs that taper in excess of 2 inches (50 millimeters) between the butt and tip ends of adjacent logs. Remove bark and at least 80 percent of the inner bark. Do not use logs with peeler or incision marks on surfaces that will be visible. Do not use logs with knot clusters, season checks, singular or any two opposite each other that exceed the thickness of the member. Logs may contain sound, tight, well-spaced knots. Treat according to AASHTO M 133.

Fabricate steel backing elements according to ASTM A2428.

710.07 Guardrail Posts. Furnish guardrail posts conforming to AASHTO-AGC-ARTBA, *A Guide to Standardized Highway Barrier Hardware*.

(a) Wood. Furnish posts that do not have a through check, shake, or end slit in the same plane as, or a plane parallel to the bolt hole and extending from the top of the post to within 3 inches (75 millimeters) or the bolt hole. Treat according to AASHTO M 133.

For steel-backed timber guardrail systems, furnish posts conforming to Subsection 710.06(c).

For steel-backed log rail systems, furnish posts conforming to Subsection 710.06(d).

(b) Steel. Furnish posts of the appropriate size shape according to ASTM A6. Zinc-coat the embedded portion of weathering steel posts according to ASTM A123.

710.08 Guardrail Blocks.

(a) Wood. Furnish wood conforming to Subsection 710.07(a).

(b) Steel. Furnish steel conforming to Subsection 710.07(b).

(c) Plastic or composite. Furnish blocks that are crashworthy. Provide a new homogeneous block with uniform texture that does not crack, chip, flake, peel, or splinter after fabrication.

710.09 Guardrail Nuts, Bolts, and Cables.

(a) Galvanized nuts and bolts. Furnish nuts conforming to ASTM A563, Grade A. Furnish bolts conforming to ASTM A307, Grade A.

(b) Weathering nuts and bolts. Furnish nuts conforming to ASTM A563, Grade C3. Furnish bolts conforming to ASTM A325, Type 3.

(c) Cable. Furnish cable conforming to AASHTO M 30, Type II, Class A.

710.10 Guardrail Hardware. Furnish hardware conforming to AASHTO-AGC-ARTBA, *A Guide to Standardized Highway Barrier Hardware*.

For angles, channels, wide flanges, and plates not contained in the above standard, conform to ASTM A36 for non-weathering steel or ASTM A242 for weathering steel. For structural tubing for short steel posts, conform to ASTM A500 or ASTM A513, Grade 1008.

Galvanize soil plates and structural tubing according to AASHTO M 111. Do not punch, drill, cut, or weld the metal after galvanizing.

Manufacture reflector tabs from 0.15-inch (4-millimeter) aluminum or plastic. Use an adhesive that resists peeling with a force of 5 pounds per inch (0.89 kilograms per centimeter) of width. Use mildew-resistant adhesive that has no staining effect on retroreflective sheeting. Furnish retroreflective sheeting conforming to ASTM D4956, including supplementary requirements.

710.11 Temporary Plastic Fence. Furnish plastic noncorrosive fence fabricated from polyethylene (HDPE) and UV stabilized for outdoor weathering. Conform to the following:

(a) Height	48 in (1200 mm) min.
(b) Mesh openings	3.15 to 3.35 in (80 to 85 mm)
(c) Color	International orange
(d) Mass	0.16 lb/ft (0.25 kg/m) min.

Section 711. — CONCRETE CURING MATERIAL AND ADMIXTURES

711.01 Curing Material. Conform to the following:

(a) Burlap cloth	AASHTO M 182
(b) Sheet material	ASTM C171
(c) Liquid membrane forming compounds	ASTM C309, Type 1-D or Type 2

711.02 Air-Entraining Admixtures. Conform to AASHTO M 154.

711.03 Chemical Admixtures. Furnish water-reducing, retarding, set-accelerating, and hydration stabilizing admixtures, or combinations thereof, conforming to AASHTO M 194. For hydration stabilizing admixtures, conform to AASHTO M 194, Type B or Type D.

711.04 Latex Emulsion. Furnish a homogeneous, nontoxic, film forming polymeric emulsion in water with stabilizers added at the point of manufacture. Conform to the following:

(a) Color	white
(b) Styrene butadiene polymer type stabilizer	68±4 percent styrene 32±4 percent butadiene
(c) Chlorides	0 percent
(d) Polymer particle size	1,500 to 2,500 Angstroms average (0.15 to 0.25 µm average)
(e) Latex	nonionic surfactant
(f) Solids	46.5 to 49.0 percent
(g) Mass	8.40 to 8.55 lb/gallon @ 77 °F (1.00 to 1.02 kg/L @ 25 °C)
(h) pH	9.0 to 13.0
(i) Shelf life	2 years min.
(j) Portland cement composition	Polydimethylsiloxene

711.05 Concrete Coloring Agents. Conform to ASTM C979. Use only coloring agents composed of synthetic or natural inorganic iron oxides.

Section 712. — JOINT MATERIAL

712.01 Sealants, Fillers, and Seals. Conform to the following:

(a) Joint sealants and crack fillers.

(1) Joint and crack sealant, hot-applied, for concrete and asphalt concrete pavements	ASTM D6690, Type II or Type III
(2) Crack filler, hot-applied, for concrete and asphalt concrete pavements	ASTM D5078

(3) Proprietary asphalt-rubber products, furnish the following:

(a) Source and grade of asphalt binder;

(b) Total quantity of granulated rubber and mass as a percent of asphalt-rubber mixture;

(c) Granulated rubber types and quantity of each type (if blend);

(1) Mass as a percent of combined rubber; and

(2) Gradation of granulated rubber.

(d) Type of asphalt modifier, if any;

(e) Quantity of asphalt modifier and mass as a percent of asphalt binder;

(f) Other additives;

(g) Heating and application temperatures; and

(h) Manufacturer’s recommended application procedures.

(4) Elastomeric joint sealant	ASTM C920, Type M, Grade P, Class 25, Use T_1 or T_2
(5) Flexible cellular joint filler	ASTM D1056, Type 2, Class B or Class C, Grades 3, 4, or 5

(b) Preformed expansion joint fillers. Furnish in a single piece for the depth and width required for the joint.

(1) Preformed expansion joint filler for concrete (bituminous type)	AASHTO M 33
(2) Preformed sponge rubber expansion joint filler for concrete paving and structural construction	AASHTO M 153, Type I
(3) Preformed cork expansion joint filler for concrete paving and structural construction	AASHTO M 153

(4) Preformed expansion joint filler for concrete paving and structural construction (nonextruding and resilient bituminous types)	AASHTO M 213

(c) Preformed polychloroprene elastomeric joint seal for concrete pavements. Conform to ASTM D2628. Use a lubricant conforming to ASTM D2835, which was manufactured within 9 months of use.

(d) Cold-applied, single component, chemically curing silicone joint sealant for concrete pavement (non-sag). Conform to ASTM D5893, Type NS.

(e) Cold-applied, single component, chemically curing silicone joint sealant for concrete pavement (self-leveling). Conform to ASTM D5893, Type SL.

(f) Backer rod. Conform to ASTM D5249, Type 1. Use a compatible sealant as recommended by the rod manufacture. For size of backer rod, conform to Table 712-1.

Table 712-1
Backer Rod Sizes

Joint Width After Preparation	Rod Diameter
5⁄16 inch (8 millimeters)	⅜ inch (10 millimeters)
⅜ inch (10 millimeters)	½ inch (13 millimeters)
½ inch (13 millimeters)	⅝ inch (15 millimeters)
⅝ inch (15 millimeters)	¾ inch (19 millimeters)
¾ inch (19 millimeters)	1 inch (25 millimeters)
1 inch (25 millimeters)	1¼ inches (32 millimeters)
1¼ inches (32 millimeters)	1½ inches (38 millimeters)
1½ inches (38 millimeters)	2 inches (50 millimeters)

(g) Preformed polychloroprene elastomeric joint seal for bridges. Conform to AASHTO M 297. Use an adhesive lubricant conforming to ASTM D4070.

712.02 Mortar. Preblend or mix on site. Furnish and proportion mortar according to ASTM C270. Use masonry cement mortar Type M or Type S.

Section 713. — ROADSIDE IMPROVEMENT MATERIAL

713.01 Topsoil.

(a) Furnished topsoil. Furnish fertile, friable, free draining, sandy loam soil that is free of subsoil, refuse, stumps, roots, brush, weeds, rocks larger than 1 inch (25 millimeters), or other substances detrimental to the development of vegetative growth. Demonstrate that the soil can sustain healthy crops of grass, shrubs, or other plant growth. Conform to the following:

(1) Texture

(a) Organic matter, AASHTO T 267	3.0 to 10.0 percent
(b) Sand, AASHTO T 88	20 to 70 percent
(c) Silt, AASHTO T 88	10 to 60 percent
(d) Clay, AASHTO T 88	5 to 30 percent
(2) pH, AASHTO T 289	6.0 to 8.0

(b) Conserved topsoil. See Subsection 204.02(c).

713.02 Agricultural Limestone. Furnish calcic or dolomitic ground limestone conforming to the standards of the Association of Official Analytical Chemists International, applicable Federal and state regulations, and the following:

(a) Purity (calcium and magnesium) carbonates	75 percent min.
(b) Gradation	Table 713-1

Table 713-1
Agricultural Limestone Gradation

Sieve Size	Minimum Percent by Mass Passing Designated Sieve (AASHTO T 27)
No. 10 (2 mm)	90
No. 40 (425 µm)	50

Granulated slag or other approved natural sources of lime may be used provided the application rate is adjusted to equal the total neutralizing power of the specified ground limestone.

713.03 Fertilizer. Furnish standard commercial grade dry formulated fertilizer conforming to the standards of the Association of Official Analytical Chemists International, applicable Federal and state regulations, and required minimum percentages of available nutrients.

Supply the fertilizer in new, clean, sealed, and properly labeled containers with name, mass, and guaranteed analysis of contents clearly marked.

Liquid fertilizer containing the minimum percentage of available nutrients may be used.

713.04 Seed. Conform to the Federal Seed Act, the Federal Noxious Weed Act, and applicable state and local seed and noxious weed laws. Do not use wet, moldy, or otherwise contaminated or damaged seed. Furnish each seed type in separate sealed container. Clearly label each container with the following:

(a) Name and type of seed;

(b) Lot number;

(c) Net mass;

(d) Percent of purity, germination, and hard seed;

(e) Percent of maximum weed seed content;

(f) Seed origin;

(g) Noxious weeds present;

(h) Other crop seed;

(i) Inert matter;

(j) Name and address of seed distributor; and

(k) Mixture percent of each component.

Inoculate legume seed with approved cultures according to the manufacturer's instructions.

713.05 Mulch.

(a) Straw. Furnish certified weed free straw from oats, wheat, rye, rice, or other grain crops that is without mold or other objectionable material. Furnish straw in an air-dry condition suitable for placing with mulch blower equipment.

(b) Wood fiber. Furnish processed wood fiber from wood chips conforming to the following:

(1) Colored with a green dye noninjurious to plant growth;

(2) Readily dispersible in water;

(3) Nontoxic to seed or other plant material;

(4) Free of growth or germination inhibiting substances;

(5) Free of weed seed;

(6) Air dried to an moisture content of 12±3 percent;

(7) Packaged in new labeled containers with the manufacturer's name; and

(8) Packaged in a condition appropriate for mixing in a homogeneous slurry suitable for application with power spray equipment.

(c) Grass straw cellulose fiber. Furnish processed grass straw fiber conforming to the following:

(1) Colored with a green dye noninjurious to plant growth;

(2) Readily dispersible in water;

(3) Nontoxic to seed or other plant material;

(4) Free of growth or germination inhibiting substances;

(5) Free of weed seed;

(6) Air dried to a moisture content of 10±0.2 percent;

(7) Air dried to a uniform mass of ±5 percent;

(8) Packaged in new containers labeled with the manufacturer's name and air-dry mass; and

(9) Packaged in a condition appropriate for mixing in a homogeneous slurry suitable for application with power spray equipment.

(d) Peat moss. Furnish a granulated sphagnum peat moss conforming to the following:

(1) Sticks, stones, and mineral matter	0 percent
(2) Partially decomposed stems and leaves of sphagnum	75 percent min.
(3) Color	Brown
(4) Textured from porous fibrous to spongy fibrous	
(5) pH	3.5 to 7.5
(6) Air-dried	

(e) Mature compost. Furnish partially decomposed organic material, (such as leaves, grass, shrubs, and yard trimmings) cured for 4 to 8 weeks. Maturity is indicated by temperature stability and soil-like odor. Furnish friable, dark brown, weed-free, and pathogen-free mature compost conforming to the following:

(1) Carbon/nitrogen ratio	25/1 to 35/1
(2) Carbon/phosphorus ratio	120/1 to 240/1
(3) pH	6.0 to 7.8
(4) Water content	40 percent max.
(5) Particle size	
(a) Seeding and sodding	½ in (12 mm) max.
(b) Erosion control	1 inch (25 mm) max.
(6) Organic material	50 percent min.
(7) Synthetic, plastic, metal, or glass material	2 percent max.

(f) Straw for hydroseeding. Furnish clean agricultural straw milled to 1 inch (25 millimeters) or less in length. Dry the fibers to 10 percent moisture for compaction. Bale in heat-sealed plastic bags.

(g) Bonded fiber matrix hydromulch. Furnish a mixture of fibers and bonding agent which, when hydraulically applied and dried, produce a matrix conforming to the following:

(1) Does not dissolve or disperse when wetted;

(2) Holds at least 10 ounces (1000 grams) of water per ounce (100 grams) of dry matrix;

(3) Has no germination or growth inhibiting factors;

(4) Forms no water insensitive crust;

(5) Contains material that is 100 percent biodegradable; and

(6) Is colored with a green dye noninjurious to plant growth.

(h) Recycled pulp fiber. Furnish cellulose fiber mulch products manufactured from natural material diverted from the waste-stream of manufacturing processes or produced from recycled material. These include newsprint, chipboard, corrugated cardboard, wood chips, and similar material. Process the material to eliminate substances that inhibit seed germination and plant growth. Add a colored dye that is non-injurious to plant growth and fades rapidly with exposure to light. Supply fiber that readily blends with water, grass seed, fertilizer, and other additives to for a slurry suitable for application with power spray equipment. Furnish a homogeneous mixture conforming to the following:

(1) Synthetic, plastic, metal, or glass material	0 percent
(2) Weed seed	0 percent
(3) Moisture content	15 percent max.
(4) Ash content	7 percent max.
(5) Organic matter	90 percent min.
(6) Boron	250 ppm max.
(7) Water-holding capacity	800 to 1200 percent by mass
(8) pH	4.0 to 8.5

(i) Wood chips. Provide wood chips from local sources including clearing. Maximum size of chips is 4 by 2 by ½ inches (100 by 50 by 13 millimeters).

713.06 Plant Material. Conform to the *American Standard for Nursery Stock*.

(a) Quality of plant material. Furnish plants that are excellent representatives of their normal species or varieties. Furnish nursery grown stock that has been transplanted or root-trimmed two or more times according to the kind and size of plant. Furnish plants with a normally developed branch system. Do not furnish plants with disfiguring knots, sun-scald, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements.

Furnish trees with reasonably straight stems and well branched and symmetrical branches according to their natural habits of growth.

(b) Plant names. For scientific and common plant names, conform to *Standardized Plant Names* as adopted by the American Joint Committee on Horticultural Nomenclature. Legibly tag and identify plants by name and size.

(c) Grading standards. Conform to *American Standard for Nursery Stock* as approved by ANSI.

(d) Nursery inspection and plant quarantine. Furnish plants that are without plant diseases and insect pests.

Comply with nursery inspection and plant quarantine regulations of the states of origin and destination including Federal regulations governing interstate movement of nursery stock. Provide a valid copy of the certificate of inspection with each package, box, bale, or carload shipped or otherwise delivered.

(e) Balled and burlapped (B&B) plants. Furnish plants from the original and undisturbed soil in which the plants were grown. Dig B&B plants to retain as many fibrous roots as possible. Wrap, transport, and handle the plants so the soil ball and small and fibrous roots remain intact.

713.07 Cellular Confinement Systems. Furnish a flexible honeycomb three-dimensional structure fabricated from light stabilized polyethylene plastic. Conform to the following:

(a) Functional longevity	120 months min.
(b) Cell area	31.0 to 46.5 in^2 (200 to 300 cm^2)
(c) Sheet thickness, ASTM D751	48.8 to 49.6 mils (1.24 to 1.26 mm)
(d) Density, ASTM D792	0.549 to 0.555 oz/in^3 (0.941 to 0.960 g/cm^3)
(e) Carbon black content, ASTM D1603	1.5 to 2.5 percent
(f) Environmental stress-cracking, ASTM D1693	2000 hours min.

(g) Conform to Table 713-2 for the depth specified.

Table 713-2
Cellular Confinement Systems

Property	Requirements				
Nominal cell depth	2 in (50 mm)	3 in (75 mm)	4 in (100 mm)	6 in (150 mm)	8 in (200 mm)
Cell joint strength	110 lb min. (500 N min.)	160 lb min. (700 N min.)	225 lb min. (1000 N min.)	315 lb min. (1400 N min.)	450 lb min. (2000 N min.)

713.08 Miscellaneous Planting Material.

(a) Stakes for bracing and anchoring. Conform to the *American Lumber Standards*. Fabricate stakes for bracing and anchoring trees from rough cypress, cedar, locust, or other approved wood essentially without knots, rot, crossgrain, or other defects that would impair the strength of the stake. Furnish stakes with a minimum 2- by 2-inch (50 by 50-millimeter) square cross-section and adequate length.

Furnish anchor stakes of the same size and quality as bracing stakes. The diameter and length of the deadman is specified in the contract.

(b) Hose. Furnish 1-inch (25-millimeter) diameter garden or steam hose (rubber and fabric) to be used with wire for bracing and anchoring trees.

(c) Wire. Furnish 0.15-inch (4-millimeter) diameter soft annealed galvanized steel wire for bracing and anchoring trees.

(d) Wrapping material. Furnish 4-inch (100 millimeter) wide rolls of waterproof paper (triple lamination 30-30-30) or 6-inch (150-millimeter) wide rolls of burlap for wrapping trees.

(e) Twine. Furnish two-ply twine for trees 3 inches (75 millimeters) and less in diameter and three-ply twine for trees over 3 inches (75 millimeters) in diameter for tying wrapping material to the trees.

(f) Antidesiccant. If approved, furnish a commercially available antidesiccant emulsion to provide a film over plant surfaces that is permeable enough to permit transpiration.

(g) Tree wound dressing. Furnish a commercially available product with asphalt base and fungicide. Furnish material that is antiseptic, waterproof, adhesive, and elastic. Do not use material that is harmful to living tree tissue (such as kerosene, coal tar, or creosote).

713.09 Sod. Furnish living vigorous sod of the type of grass and thickness specified in the contract. Furnish sod with a dense root system that is reasonably free of noxious weeds and grasses. Before taking up the sod, cut the top growth to less than 3-inch (75-millimeter) height.

713.10 Pegs for Sod. Furnish square or round pegs of sound wood conforming to the following:

(a) Length — 8 in (200 mm) min.

(b) Approximate cross-sectional area — 1 in^2 (600 mm^2)

713.11 Tackifiers. Furnish a commercially available product containing no solvents or other diluting agents toxic to plant life that is without growth or germination inhibiting factors, nonflammable, nontoxic to aquatic organisms, and functional for at least 180 days.

(a) General purpose tackifier. Furnish one of the following:

(1) Plant based tackifier. Furnish a natural high molecular weight polysaccharide, a high viscosity hydrocolloid that is miscible in water, and labeled as one of the following:

(a) Guar gum. A product derived from the ground endosperm of the guar plant, Cyamopsis tetragonolobus, treated with dispersing agents for easy mixing and dilutable at the rate of 1 to 5 pounds per 100 gallons (1.2 to 6 kilograms per 1000 liters) of water.

(b) Psyllium. A product manufactured from the finely ground mucilloid coating of Plantago ovata or Plantago ispaghula seeds; able to dry and form a firm, but rewettable membrane.

(c) Starch. A product manufactured from a nonionic, water-soluble, granular material derived from corn, potato, or other plant-based source.

(2) Polymeric emulsion blend tackifier. Furnish a prepackaged liquid or dry powder, anionic formulation with a residual monomer content not exceeding 0.05 percent by mass and labeled with one of the following as the primary active ingredient:

(a) Acrylic copolymers and polymers;

(b) Polymers of methacrylates and acrylates;

(c) Copolymers of sodium acrylates and acrylamides;

(d) Polyacrylamide and copolymer of acrylamide; or

(e) Hydrocolloid polymers.

(b) Polymer stabilized fiber matrix tackifier. Furnish the following:

(1) A liquid formulation with polyacrylamide as the primary active ingredient with the following requirements:

(a) Linear, anionic copolymer of acrylamide and sodium acrylate; and

(b) Anionic with a residual monomer content that is at most 0.05 percent by mass.

(2) Formulated and labeled as one of the following:

(a) Water-in-oil emulsion. A product containing at least 2.6 pounds per gallon (3.1 kilograms per 10 liters) pure polyacrylamide that is at least 30 percent active; or

(b) Liquid dispersed polyacrylamide. A product containing at least 4.4 pounds per gallon (5.3 kilograms per 10 liters) pure polyacrylamide that is at least 35 percent active.

713.12 Fiber Rolls and Socks.

(a) Excelsior fiber rolls. Furnish fiber rolls of curled excelsior fiber rolled into a cylindrical shape and encased in a tubular netting.

(b) Straw fiber rolls. Furnish straw fiber rolls that are manufactured from certified weed free straw and wrapped in a tubular mesh.

(c) Coir rolls. Furnish coir fiber rolls that are 100 percent coconut fiber.

(d) Compost socks. Furnish tubular mesh filled with mature compost according to Subsection 713.05(e).

(e) Tubular mesh for fiber rolls. Provide tubular mesh with openings no larger than ⅜ inch (10 millimeters). Mesh material is not required to be biodegradable, but must be removed at the end of the project if it is not biodegradable. Provide tubular mesh diameter according to plans. Fill according to manufacturer's recommendations.

(f) Other fiber material. Use of recycled material that meet the requirements of the application may be considered. Submit to the CO for approval.

713.13 Gravel Bags. Furnish woven fabric bags with a minimum water flow rating of 145 gallons per minute per foot (1.8 cubic meters per minute per meter) as tested by ASTM D4491. Fill the bags with clean coarse aggregate.

713.14 Sandbags. Use clean, silt free material for sand filler. Conform to the following:

(a) Bag material	canvas, geotextile, or burlap
(b) Volume per bag	⅓ ft^3 (0.01 m^3) min.

713.15 Temporary Culvert Pipe. For temporary slope drains and temporary culvert pipes, furnish culvert pipe fabricated from corrugated metal, plastic, or concrete for use in diverting water through or around work areas. Furnish temporary culvert pipe placed beneath the traveled way conforming to HS-20 (M-18) loading rating in AASHTO, *Load and Resistance Factor Design (LRFD) Bridge Design Specifications.*

713.16 Silt Fence.

(a) Geotextile. Conform to Table 7 of AASHTO M 288.

(b) Posts. Conforming to the following:

(1) Wood posts. Conform to the following:

(a) 1½ inches by 1½ inches by 4 feet (38 millimeters by 38 millimeters by 1.2 meters) minimum dimensions;

(b) Untreated fir, redwood, cedar, or pine, cut from sound timber with no loose or unsound knots; and

(c) Pointed on end driven in ground.

(2) Steel posts. Conform to the following:

(a) 48 inches (1200 millimeter) minimum length;

(b) Cross-section shape that can resist failure from lateral loads (T-shaped, U-shaped, or L-shaped); and

(c) 0.75 pound per foot (1.1 kilograms per meter) minimum mass.

(c) Silt fence reinforcement. Furnish a wire mesh consisting of 14 gauge (1.628-millimeter diameter) steel with mesh spacing of 6 by 6 inches (150 by 150 millimeters) or prefabricated polymeric mesh of equivalent strength.

713.17 Temporary Rolled Erosion Control Products. Furnish temporary rolled erosion control products conforming to Table 713-3 and the following. See the Erosion Control Technology Council website (ECTC.org) for commercially available products that may conform to these specifications.

(a) Type 1.A, ultra-short term mulch control netting. Furnish a mulch control netting consisting of rapidly degrading photodegradable synthetic mesh or woven biodegradable natural fiber netting.

(b) Type 1.B, ultra-short term net-less erosion control blanket. Furnish an erosion control blanket composed of processed rapidly degrading natural or polymer fibers mechanically interlocked or chemically adhered together to form a continuous matrix.

(c) Type 1.C, ultra-short term single-net erosion control blanket and open weave textile. Furnish one of the following material:

(1) An erosion control blanket composed of processed degradable natural or polymer fibers mechanically-bound together by a single rapidly degrading, synthetic or natural fiber netting to form a continuous matrix; or

(2) An open weave textile composed of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.

(d) Type 1.D, ultra-short term double-net erosion control blankets. Furnish an erosion control blanket composed of processed natural or polymer fibers mechanically-bound between two rapidly degrading, synthetic, or natural fiber nettings to form a continuous matrix.

(e) Type 2.A, short-term mulch control netting. Furnish a mulch control netting consisting of photodegradable synthetic mesh or woven biodegradable natural fiber.

(f) Type 2.B, short-term net-less erosion control blanket. Furnish an erosion control blanket composed of processed degradable natural or polymer fibers mechanically-interlocked or chemically-adhered together to form a continuous matrix.

(g) Type 2.C, short-term single-net erosion control blanket or open weave textile. Furnish one of the following material:

(1) An erosion control blanket composed of processed degradable natural or polymer fibers mechanically-bound together by a single degradable synthetic or natural fiber netting to form a continuous matrix; or

(2) An open weave textile composed of processed degradable natural or polymer yarns or twines woven into a continuous matrix.

(h) Type 2.D, short-term double-net erosion control blankets. Furnish an erosion control blanket composed of processed natural or polymer fibers mechanically bound between two natural fiber or synthetic nettings to form a continuous matrix.

(i) Type 3.A, extended term mulch control netting. Furnish a mulch control netting consisting of a slow degrading synthetic mesh or woven natural fiber.

(j) Type 3.B, extended term erosion control blanket or open weave textile. Furnish one of the following material:

(1) An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically-bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix; or

(2) An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.

(k) Type 4, long-term erosion control blanket or open weave textile. Furnish one of the following material:

(1) An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically-bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix; or

(2) An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.

Table 713-3
Temporary Rolled Erosion Control Products

Rolled Erosion Control Product Type												
Property	**Test Method**	**1.A[1]**	**1.B**	**1.C**	**1.D**	**2.A [1]**	**2.B**	**2.C**	**2.D**	**3.A [1]**	**3.B**	**4**
Typical functional longevity[2] (months)	N/A	3	3	3	3	12	12	12	12	24	24	36
Minimum tensile strength	ASTM D6818	5 lb/ft (0.73 kN/m)	5 lb/ft (0.73 kN/m)	50 lb/ft (0.73 kN/m)	75 lb/ft (0.73 kN/m)	5 lb/ft (0.73 kN/m)	5 lb/ft (0.73 kN/m)	50 lb/ft (0.73 kN/m)	75 lb/ft (1.09 kN/m)	25 lb/ft (0.36 kN/m)	100 lb/ft (1.45 kN/m)	125 lb/ft (1.82 kN/m)
Maximum "C" factor at maximum gradient for slope applications[3]	ASTM D6459 or other qualified independent test[6]	0.10 at 1V:5H	0.10 at 1V:4H	0.15 at 1V:3H	0.20 at 1V:2H	0.10 at 1V:5H	0.10 at 1V:4H	0.15 at 1V:3H	0.20 at 1V:2H	0.10 at 1V:5H	0.25 at 1V:1½H	0.25 at 1V:1H
Minimum shear stress for channel applications[4][5]	ASTM D7207 or other qualified independent test[6]	0.25 lb/ft^2 (12 Pa)	0.50 lb/ft^2 (24 Pa)	1.50 lb/ft^2 (72 Pa)	1.75 lb/ft^2 (84 Pa)	0.25 lb/ft^2 (12 Pa)	0.50 lb/ft^2 (24 Pa)	1.50 lb/ft^2 (72 Pa)	1.75 lb/ft^2 (84 Pa)	0.25 lb/ft^2 (12 Pa)	2.00 lb/ft^2 (96 Pa)	2.25 lb/ft^2 (108 Pa)

(1) Obtain max "C" factor and allowable shear stress for mulch control nettings with the netting used in conjunction with pre-applied mulch material.

(2) Functional longevities are for guidance only. Actual functional longevities may vary based on site and climatic conditions.

(3) "C" factor calculated as ratio of soil loss from rolled erosion control product protected slope (tested at specified or greater gradient, v:h) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC), Test Method #2.

(4) Minimum shear stress the rolled erosion control product (un-vegetated) can sustain without physical damage or excess erosion (> ½-inch (> 12.7-millimeter) soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ECTC, Test Method #3.

(5) The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 to 0.05.

(6) Other large-scale test methods determined acceptable by the CO.

713.18 Turf Reinforcement Mats. Furnish a rolled erosion control product composed of non-degradable synthetic fibers, filament, nets, wire mesh, and other elements processed into a permanent, three-dimensional matrix conforming to Table 713-4. See the Erosion Control Technology Council website (ECTC.org) for commercially available products that may conform to these specifications.

Table 713-4
Turf Reinforcement Mats

Properties[(1)]	Test Method	Rolled Erosion Control Product Type		
		5.A	**5.B**	**5.C**
Minimum tensile strength[(2)(3)]	ASTM D4595	125 lb/ft (1.82 kN/m)	150 lb/ft (2.19 kN/m)	175 lb/ft (2.55 kN/m)
UV stability (minimum % tensile retention)	ASTM D4355 (500-hour exposure)	80	80	80
Minimum thickness[(2)]	ASTM D6525	¼ in (6.35 mm)	¼ in (6.35 mm)	¼ in (6.35 mm)
Maximum gradient for slope applications	–	2V:1H	2V:1H	2V:1H
Minimum shear stress for channel applications[(4)]	ASTM D6460 or other qualified independent test[(5)]	6.0 lb/ft^2 (288 Pa)	8.0 lb/ft^2 (384 Pa)	10.0 lb/ft^2 (480 Pa)

(1) For turf reinforcement mats containing degradable components, obtain property values on the non-degradable portion of the matting alone.

(2) Minimum average roll values, machine direction only.

(3) Field conditions with high loading and high survivability requirements may warrant the use of turf reinforcement mats with tensile strengths of 3,000 pounds per foot (44 kilonewtons per meter) or greater.

(4) Minimum shear stress the turf reinforcement mat (fully vegetated) can sustain without physical damage or excess erosion (> ½-inch (> 12.7-millimeter)soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council, Test Method #3.

(5) Other large-scale test methods determined acceptable by the CO.

713.19 Sediment Filter Bags. Furnish rot and mildew resistant bags composed of a non-woven geotextile fabric conforming to Table 713-5 and the following:

(a) Minimum footprint 150 ft^2 (14 m^2)

(b) Sewn-in sleeve to fit minimum 4-inch (100-millimeter) pump discharge hose.

Secure discharge hose with a hose clamp.

Table 713-5
Sediment Filter Bag Geotextile Requirements

Property	Test Method ASTM	Units	Specifications
Mass	D3776	oz/yd (g/m)	10.0 (310)
Minimum grab tensile strength	D4632	lb (N)	250 (1100)
Tensile elongation at break	D4632	%	50
Minimum puncture strength	D4833	lb (N)	115 (510)
Minimum trapezoid tear strength	D4533	lb (N)	100 (445)
Minimum sewn seam strength	D4632	lb (N)	200 (900)
Mullen burst	D3786	lb/in^2 (kPa)	350 (2400)
Ultraviolet resistance	D4355	%	70
Permittivity	D4491	sec^{-1}	1.2
Water flow rate	D4491	gal/min./ft (m^3/min./m)	145 (1.8)

713.20 Prefabricated Filter Insert. Size inlet filter inserts to fit the catch basin or drop inlet and provide a high-flow bypass. Follow manufacturer's recommendations.

713.21 Floating Turbidity Curtains. Furnish curtains made of tightly woven nylon, plastic, or other non-deteriorating material conforming to Table 713-6 and the following:

(a) Fabric overlap when more than one width of fabric is required — 6 in (150 mm)

(b) Supporting flotation buoyancy — 29 lb/ft (1.4 kPa) min.

(c) Ballast chain (galvanized) — $^5/_{16}$ in (8 mm)

(d) Dual galvanized wire rope load lines with a heavy vinyl coating — $^5/_{16}$ in (8 mm) diameter

Table 713-6
Floating Turbidity Curtain Material Requirements

Property	Test Method ASTM	Units	Specifications
Minimum grab tensile strength: machine direction	D4632	lb (N)	370 (1640)
Minimum grab tensile strength: cross machine direction	D4632	lb (N)	250 (1110)
Trapezoid tear strength: machine direction	D4533	lb (N)	100 (445)
Trapezoid tear strength: cross-machine direction	D4533	lb (N)	60 (270)
Mullen burst	D3786	lb/in^2 (kPa)	480 (3300)
Apparent opening size	D4751		70
4% permittivity	D4491	sec^{-1}	0.28

Section 714. — GEOSYNTHETIC MATERIAL

714.01 Geotextile. Use long-chain synthetic polymers composed of at least 95 percent by mass of polyolefins or polyesters to manufacture geotextile and the threads used in joining geotextile by sewing. Form the geotextile, including selvedges, into a stable network such that the filaments or yarns retain their dimensional stability relative to each other.

Property values, with the exception of apparent opening size (AOS), in these specifications represent minimum average roll value (MARV) in the weakest principal direction (that is average test results of any roll in a lot sampled for conformance or quality assurance testing must meet or exceed the specified values). Values for AOS represent maximum average roll values.

Conform to the following physical requirements:

(a) Separation and stabilization geotextile and geotextile filter. Conform to Table 714-1.

Table 714-1
Separation and Stabilization Geotextile and Geotextile Filter Requirements (1)

Strength and Durability Properties						
Property	**Test Method ASTM**	**Units**	**Class 1**		**Class 2**	
Type of Geotextile			**Woven**	**Nonwoven**	**Woven**	**Nonwoven**
Elongation at break	D4632	%	< 50	≥ 50	< 50	≥ 50
Minimum grab strength	D4632	lb (N)	320 (1420)	200 (890)	250 (1110)	160 (710)
Minimum sewn seam strength	D4632	lb (N)	290 (1290)	180 (800)	220 (980)	140 (620)
Minimum tear strength	D4533	lb (N)	110 (490)	80 (360)	90 (400)	55 (240)
Minimum puncture strength	D6241	lb (N)	620 (2760)	430 (1910)	500 (2220)	310 (1380)
Minimum ultraviolet stability	D4355	%	50% retained strength after 500 hours of exposure			

Hydraulic Properties							
Property	**Test Method ASTM**	**Units**	**Type A**	**Type B**	**Type C**	**Type D**	**Type E**
Minimum permittivity	D4491	s^{-1}	0.7	0.5	0.2	0.1	0.1
Maximum apparent opening size (AOS)	D4751	Sieve size U.S. (mm)	No. 40 (0.425)	No. 40 (0.425)	No. 60 (0.250)	No. 40 (0.425)	No. 70 (0.212)

(1) Do not use woven slit film geotextile.

(b) Paving geotextile. Furnish nonwoven geotextile conforming to Table 714-2.

Table 714-2
Paving Geotextile Requirements

Property	Test Method ASTM	Units	Specifications
Grab strength	D4632	lb (N)	110 (490)
Elongation at break	D4632	%	≥ 50
Asphalt retention	D6140	gal/yd^2 (L/m^2)	See Note (1)
Mass per unit area	D5261	oz/yd^2 (g/m^2)	4 - 6 (135 - 200)
Melting point	D276	ºF (ºC)	300 (150)

(1) Asphalt required to saturate fabric only. Value supplied by manufacturer in material certification. Value does not indicate the asphalt application rate required for construction. Product asphalt retention property must meet the MARV provided by the manufacturer's certification.

714.02 Geocomposite Drain. Furnish a prefabricated geocomposite drain composed of a drainage core and a nonwoven geotextile that permits in-flow from both sides. Geocomposites that only permit in-flow from one side may only be used directly against a concrete surface. Furnish geotextile and drainage core manufactured from long chain synthetic polymers composed at least 95 percent by mass of polypropylene, polyester, polyamide, polyvinyl chloride, polyolefin, or polystyrene. Build the core up in thickness by columns, cones, nubs, cusps, meshes, stiff filaments, or other configurations. Fabricate the core in sheets, panels, or rolls of adequate strength to resist installation stresses and long-term loading conditions.

Property values, with the exception of fungi resistance, in these specifications represent MARV in the weakest principal direction (that is average test results of any roll in a lot sampled for conformance or quality assurance testing must meet or exceed the specified values).

Furnish a nonwoven encapsulating geotextile meeting requirements of Table 714-1. Firmly attach the encapsulating geotextile to the core at the manufacturing plant, so that folding, wrinkling, or other movement cannot occur during handling or after placement. Use a nonwater-soluble adhesive, heat sealing, or other methods recommended by the geotextile manufacturer. Do not use adhesive on areas of the geotextile where flow is intended to occur.

If heat sealing is used, do not weaken the geotextile below the required strength values. Extend the geotextile beyond the core length on all sides sufficiently to encapsulate the core and collector pipe.

Conform to Table 714-3.

Table 714-3
Geocomposite Drain Requirements

Property	Test Method	Units	Specifications		
			Sheet Drain	Strip Drain	
			Type 1	Type 1	Type 2
Transmissivity (flow rate) [1]	ASTM D4716	gal/min/ft (m^3/sec/m)	5.0 (0.0010)	15.0 (0.0031)	20.0 (0.0041)
Compressive strength at yield	ASTM D1621	psi (kPa)	100 (690)	50 (340)	50 (340)
Applied normal compressive stress	ASTM D4716[4]	psi (kPa)	14.5 (100)	1.45 (10)	1.45 (10)
Hydraulic gradient	ASTM D4716[2][3][4]	dimensionless	1.0	0.1	0.1
Fungi resistance	ASTM G21	−	No visible growth		

(1) If core construction separates the flow channel into two or more discrete sections, only the flow rate on one in-flow face is considered in determining the core's acceptability.

(2) 14-inch (350 millimeter) long specimen.

(3) 100-hour seating period.

(4) Rubber membrane between platens and geocomposite.

714.03 Stabilization Geogrid. Furnish biaxial geogrid manufactured using long-chain synthetic polymers composed of at least 95 percent by mass of polyolefins, polyesters, or polyamides. Fabricate the geogrid into a stable network such that the ribs, filaments, or yarns retain their dimensional stability relative to each other, including selvages.

Property values, with the exception of maximum opening size, represent MARV (that is average test results of any roll in a lot sampled for conformance or quality assurance testing must meet or exceed the minimum specified values). The value for maximum opening size represents maximum average roll value.

Conform to Table 714-4.

Table 714-4
Stabilization Geogrid Requirements

Property	Test Method	Specifications[1]
Minimum opening size	N/A[2]	½ in (13 mm)
Maximum opening size	N/A[2]	3 in (75 mm)
Tensile strength at 2% strain	ASTM D6637	400 lb/ft (5.8 kN/m)
Tensile strength at 5% strain	ASTM D6637	800 lb/ft (11.7 kN/m)
Ultimate tensile strength	ASTM D6637	1300 lb/ft (19.0 kN/m)
Junction strength	GRI[3] GG2	25 lb (110 N)
Ultraviolet stability	ASTM D4355	50% retained strength after 500 hours of exposure

(1) Strength values are in the weaker principal direction.
(2) Direct measure with caliper.
(3) Geosynthetic Research Institute.

714.04 Reinforcement Geotextile and Geogrid. Furnish reinforcement geotextile manufactured using long-chain, synthetic polymers, composed at least 95 percent by mass of polyolefins or polyesters. Form the geotextile, including selvedges, into a stable network such that the filaments or yarns retain their dimensional stability relative to each other.

Furnish reinforcement geogrid manufactured as a regular network of integrally-connected longitudinal and transverse polymer tensile elements with a geometry that permits significant mechanical interlock with the backfill. Provide geogrid composed of fibers or ribs that are at least 95 percent by mass polypropylene, polyethylene, or polyester. The geogrid structure must remain dimensionally stable under construction stresses and have a high resistance to damage during construction, to ultraviolet degradation, and to chemical and biological degradation encountered in the soil being reinforced.

Conform to Tables 714-5 and Table 714-6. Property values represent MARV (that is average test results of any roll in a lot sampled for conformance or quality assurance testing must meet or exceed the minimum specified values).

The nominal long-term strength (T_{al}) is based on:

$$T_{al} = T_{ult}/RF$$

where $RF = RF_{ID} \times RF_{CR} \times RF_{D}$.

RF_{ID}, RF_{CR}, and RF_{D} values must be substantiated by evaluation of independent test results by Highway Innovative Technology Evaluation Center (HITEC), AASHTO National Transportation Product Evaluation Program (NTPEP), or an equivalent third party report. Provide a copy of the report to the CO. Determine RF_{ID}, RF_{CR}, and RF_{D} according to the following:

(a) RF_{ID}: Determine the reduction factor for installation damage from the results of full scale construction damage tests conducted according to ASTM D5818. Conduct the tests with a soil having the same maximum particle size, D_{50}, and angularity as the soil to be used for construction. Tests using coarser soils (same or larger maximum particle size and D_{50}) may be an acceptable substitution. The CO will make the final determination as to whether the test data based on the substitute soil is acceptable. Interpolation of RF_{ID} will not be allowed, the results for the coarser soils will be used. The Contractor may elect to perform a test using project specific fill, placement, and compaction techniques and equipment to determine the RF_{ID}. Use a default value of 3.0 if no installation damage testing has been conducted. The minimum value for RF_{ID} is 1.1.

(b) RF_{CR}. Determine the creep reduction factor according to one of the following:

(1) Conventional creep testing according to ASTM D5262; or

(2) A combination of Stepped Isothermal Method (SIM) according to ASTM D6992 and conventional creep testing. Perform testing and determine creep reduction factors for a 75 year design life according to the procedures in Appendix D of FHWA-NHI-10-025, *Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume II*. If testing has not been conducted, default values for RF_{CR} are 2.5 for polyester polymer, and 5.0 for polypropylene or polyethylene polymer.

(c) RF_D. For polypropylene or polyethylene geosynthetics conforming to the requirements of Table 714-5, a default reduction factor of 1.1 may be used for RF_D. For polyester geosynthetics conforming to the requirements of Table 714-5, a default reduction factor of 1.15 may be used for RF_D if the soil has a pH between 5 and 8; and a reduction factor of 1.3 may be used if the soil pH is between 3 and 5 or between 8 and 9.

Table 714-5
Reinforcement Geotextile and Geogrid Polymer Requirements

Polymer Type	Property	Test Method	Specifications
Polypropylene and polyethylene	Thermo-oxidation resistance	ENV ISO 13438, Method A (polypropylene) or Method B (polyethylene)	Minimum 50% retained strength after 28 days (polypropylene) or 56 days (polyethylene)
Polyester	Hydrolysis resistance	Inherent Viscosity Method ASTM D4603 & GRI (1) GG8	Minimum number average molecular weight (M_n) of 25,000
	"	GRI (1) GG7	Maximum carboxyl end group (CEG) of 30
All polymers	Ultraviolet stability	ASTM D4355	Minimum 70% retained strength after 500 hours of exposure
	Mass per unit area	ASTM D5261	Minimum 8 oz/yd^2 (270 g/m^2)
	Percent post consumer recycled material by mass	Certification of material used	Maximum 0%

(1) Geosynthetic Research Institute.

Table 714-6
Reinforcement Geotextile and Geogrid Strength Requirements

Property	Test Method ASTM	Units	Specifications[1][2]					
			Type I	Type II	Type III	Type IV	Type V	Type VI
Ultimate strength [3] (T_{ult})	D4595 or D6637 [4]	lb/ft (kN/m)	2000 (29.2)	3000 (43.8)	4000 (58.4)	5000 (73.0)	6000 (87.6)	8000 (116.8)
Nominal long-term strength (T_{al})	See Note (5)	lb/ft (kN/m)	1000 (14.6)	1500 (21.9)	2000 (29.2)	2500 (36.5)	3000 (43.8)	4000 (58.4)

(1) For reinforcement geotextile, also meet the Class 1 strength requirements in Table 714-1 and the ultraviolet stability requirements in Table 714-5.

(2) The specified strength is in the principal direction of reinforcement (that is perpendicular to the wall or slope face).

(3) Based on MARV.

(4) ASTM D4595 is for reinforcement geotextile and ASTM D6637 is for geogrid.

(5) See the nominal long-term strength (T_{al}) formula above.

714.05 Geomembrane. Furnish geomembrane that consists of textured (roughened) surface polyvinyl chloride, high density polyethylene, or linear low density polyethylene geomembrane with a thickness of 28.5 to 31.5 mils (0.72 to 0.80 millimeters). Glue or weld seams of the geomembrane to prevent leakage.

Conform to Table 714-7.

Table 714-7
Geomembrane Requirements

Geomembrane Type	Test Method
Polyvinyl chloride (PVC)	ASTM D7176[1]
High density polyethylene (HDPE)	GRI[2] Test Method GM13
Linear low density polyethylene (LLDPE)	GRI[2] Test Method GM17

(1) The minimum average asperity height is 10 mils (0.25 millimeters). Of 10 readings, 8 of 10 must be greater than or equal to 7 mils (0.18 millimeters) and the lowest individual reading must be greater than or equal to 5 mils (0.12 millimeters).

(2) Geosynthetic Research Institute.

Section 715. — PILING

715.01 Untreated Timber Piles. Conform to AASHTO M 168. Fabricate the piles from the following species (or group) for the sizes and dimensions specified in the contract:

(a) Douglas-fir;

(b) Larch;

(c) Red pine;

(d) Red oak; or

(e) Southern pine.

715.02 Treated Timber Piles. Conform to AASHTO M 133 and AASHTO M 168. Use Douglas-fir or southern pine.

Use the pressure method procedure prescribed in AWPA. Apply the treatment to the piles after millwork is completed.

Imprint legible symbols or legend on the end of piles identifying the name of the treating company and type and year of treatment according to AWPA Standards M1, *Standard for the Purchase of Treated Wood Products* and M6 *Brands used on Forest Products*.

715.03 Concrete Piles. Fabricate piles from Class A (AE) concrete according to Section 552. Conform to Subsection 709.01 for reinforcing steel. Conform to Subsection 709.02 for prestressing steel.

Construct precast concrete piles according to Section 552. Construct prestressed concrete piles according to Section 553. When lifting anchors are used, maintain at least a 1-inch (25-millimeter) clearance from the pile reinforcing steel or prestressing steel.

Use metal, plywood, or dressed lumber forms that are watertight, rigid, and true to line. Use a 1-inch (25-millimeter) chamfer strip in corners of the forms.

Cast piles separately or, if alternate piles are cast in a tier, cast the intermediate piles at least 4 days after the adjacent piles are poured. Separate piles cast in tiers with tar paper or other suitable separating material. Place concrete in each tier in a continuous operation that prevents the formation of stone pockets, honeycombs, or other defects. Leave forms in place for at least 24 hours.

Make piles straight so when a line is stretched from butt to tip on any face, the line is no more than 1 inch (25 millimeters) from the face of the pile at any point. Make the pile surface true, smooth, even, and without honeycombs and voids.

Remove lifting anchors to a depth of at least 1 inch (25 millimeters) below the concrete surface and fill the resulting hole with concrete. Finish each pile with a Class 1 ordinary surface finish according to Subsection 552.16. Cure the piles according to Sections 552 and 553 as applicable.

If concrete test cylinders are made and tested according to Section 552, do not move piles until the tests indicate a compressive strength of at least 80 percent of the design 28-day compressive strength. Do not transport or drive piles until tests indicate the minimum design 28-day compressive strength is attained.

If concrete test cylinders are not made, do not move piles until they have cured for at least 14 days at a minimum temperature of 60 °F (15 °C) or 21 days at a minimum temperature of 40 °F(4 °C). Do not transport or drive piles until cured for at least 21 days at at least 60 °F (15 °C) or 28 days at at least 40 °F (4 °C). When high-early-strength cement is used, do not move, transport, or drive piles until cured for at least 7 days.

715.04 Steel Shells. Furnish either cylindrical or tapered pile shells of spiral welded, straight-seam welded, or seamless tube steel material. Use only one type of pile shell throughout a structure. Conform to the following minimum shell wall thicknesses:

• Outside cylinder diameter less than 14 in (350 mm)	¼ in (6 mm)
• Outside cylinder diameter greater than or equal to 14 in (350 mm)	⅜ in (10 mm)
• Tapered or fluted	$^{3}/_{16}$ in (5 mm)

(a) Shells driven without a mandrel. For tapered or step tapered cast-in-place concrete piles, furnish shells having a minimum 12-inch (300-millimeter) diameter at cutoff and a minimum 8-inch (200-millimeter) diameter tip. Furnish shells having a minimum nominal diameter of 10¾ inches (270 millimeters) for constant diameter cast-in-place concrete piles.

Fabricate shells from not less than $^{3}/_{16}$-inch (5-millimeter) plate stock conforming to ASTM A36. Shells may be either spirally welded or longitudinally welded and may be either tapered or constant in section. Seal the tips as noted on the drawings.

(b) Shells driven with a mandrel. Furnish shells of sufficient strength and thickness to withstand driving without injury and to resist harmful distortion and buckling due to soil pressure after being driven and the mandrel removed. Butt and tip dimensions are specified in the contract.

715.05 Steel Pipes. Conform to the following:

(a) Steel pipe to be filled with concrete	ASTM A252, Grade 2 or Grade 3
(b) Closure plates for closed end piles	ASTM A572, ASTM A588, or ASTM A690, Grade 50 (345)
(c) Unfilled tubular steel piles for welded and seamless steel pipe piles with chemical properties conforming to ASTM A53, Grade B	ASTM A252, Grade 2 or Grade 3

715.06 Steel H-Piles. Furnish steel H-piles from rolled steel sections of the mass and shape specified. Fabricate the H-piles from structural steel conforming to ASTM A572, ASTM A588, or ASTM A690, Grade 50 (345).

For copper-bearing structural steel, furnish steel with 0.20 to 0.35 percent copper.

715.07 Sheet Piles. Conform to AASHTO M 202 or ASTM A572 for steel sheet piles.

715.08 Pile Shoes. For timber and steel piles, furnish prefabricated cast steel shoes or driving points conforming to ASTM A27, Grade 65-35 (450-240) or ASTM A148, Grade 90-60 (620-415).

715.09 Splices. Manufacture splices from structural steel conforming to ASTM A572, ASTM A588, or ASTM A690, Grade 50 (345) for H or pipe piles.

Section 716. — MATERIAL FOR TIMBER STRUCTURES

716.01 Untreated Structural Timber and Lumber. Conform to AASHTO M 168. Furnish an inspection certification from an agency accredited by the American Lumber Standards Committee for the species and grade. Mark pieces with the inspection service, grade designation, species, and inspector identity.

Season and dry structural timber and lumber before fabrication. Do not use material that is twisted, curved, or otherwise distorted.

Do not use boxed-heart pieces of Douglas fir or redwood in outside stringers, floor beams, caps, posts, sills, or rail posts. Boxed-heart pieces are defined as timber so sawed that, at any point in the length of a sawed piece, the pith lies inside the four faces.

716.02 Hardware. Machine bolts, drift bolts and dowels may be medium steel. Fabricate washers from gray iron or malleable iron castings unless structural washers are specified.

Use a standard commercial type of cut or round nail. Use cut, round, or boat spikes as specified.

Galvanize hardware according to AASHTO M 232.

Use ring or shear-plate timber connectors conforming to Division II, Article 16.2.6, *Timber Connectors* of AASHTO *LRFD Bridge Construction Specifications for Highway Bridges*.

716.03 Treated Structural Timber and Lumber. Furnish wood according to Subsection 716.01. Make dimensional cuts, holes, and incise wood before pressure treatment. Treat the wood according to AWPA Standard U1, *Use Specification for Treated Wood* and T1 *Processing and Treatment Standard*. Use the type of treatment shown in the plans.

Treat timber members according to the requirements of the current edition of Western Wood Preservers Institute's *Best Management Practices for the Use of Treated Wood in Aquatic Environments*.

Treated timber members must have a quality mark approved by the American Lumber Standards Committee for individual pieces or sealed pallets assuring that treatment conforms to the appropriate AWPA standards.

716.04 Structural Glued Laminated Timber. Furnish structural glued laminated timber according to American Institute of Timber Construction's AITC 117, *Design Specifications for Structural Glued Laminated Timber of Softwood Species*. Fabricate according to the combination and grade as indicated in the contract. Fabricate structural glued laminated members according to ANSI/AITC A190.1, *American National Standard for Structural Glued Laminated Timber*.

Manufacture members as industrial appearance grade for wet use conditions. Use adhesives conforming to the requirements of ASTM D2559 and AITC 405, *Standard for Wood Products - Structural Glued Laminated Timber*. Use only single- or multiple-piece laminations with bonded edge joints.

Straight or slightly cambered members which are to be loaded perpendicular to the wide face of the laminates must be stamped "*top*" on the top at both ends of the beam.

Section 717. — STRUCTURAL METAL

717.01 Structural Steel.

(a) Structural carbon steel. Conform to the following:

(1) Primary bridge members	AASHTO M 270, Grade 36T (250T)
(2) Fracture critical bridge members	AASHTO M 270, Grade 36F (250F)
(3) Other shapes, plates, and bars	AASHTO M 270, Grade 36 (250)

(b) High-strength low-alloy structural (HSLA) steel. Conform to the following:

(1) Primary bridge members and welded members	AASHTO M 270, Grade 50T, 50ST, 50WT, or HPS 50WT (345T, 345ST, 345WT, or HPS 345WT)
(2) Fracture critical bridge members and fracture critical welded members	AASHTO M 270, Grade 50F, 50SF, 50WF, or HPS 50WF (345F, 345SF, 345WF, or HPS 50SF)
(3) Other shapes, plates, and bars	AASHTO M 270, Grade 50, 50S, 50W, or HPS 50 (345, 345S, 345W, or HPS 345)

(c) High-strength quenched and tempered (QT) steel. Conform to the following:

(1) Primary bridge members	AASHTO M 270, Grade 70WT, HPS 70WT, 100T, 100WT, or HPS 100WT (485WT, HPS 485WT 690T, 690WT, or HPS 690WT)
(2) Fracture critical bridge members	AASHTO M 270, Grade 70WF, HPS 70WF, 100F, 100WF, or HPS 100WF (485WF, HPS 485WF 690F, 690WF, or HPS 690WF)
(3) Other shapes, plates, and bars	AASHTO M 270, Grade 70W, HPS 70W, 100, 100W, or HPS 100W (485W, HPS 485W, 690, 690W, or HPS 690W)
(4) Hollow structural sections	ASTM A500, Grade B, ASTM A501, ASTM A847, or ASTM A618

(d) Bolts and nuts. Conform to ASTM F1554, Grade 36 (250) or ASTM A307 as shown in the plans. Furnish nuts conforming to ASTM A563 for appropriate grade and size of anchor bolt. Heat treat nuts to be galvanized to Grade DH or Grade DH3. Lubricate galvanized nuts with a lubricant containing a visible dye.

(e) High-strength bolts, nuts, and washers. Conform to ASTM A325 or ASTM A490 as specified. Use Type 1 bolts with steels other than weathering steel. Use Type 3 bolts with weathering steel.

ASTM A325, Type 1 bolts may be either hot-dip galvanized according to AASHTO M 232, Class C or mechanically galvanized according to ASTM B695, Class 50. Retest galvanized bolts after galvanizing according to ASTM A325. Do not galvanize ASTM A490 bolts.

Galvanize washers, nuts, and bolts of any assembly by the same process. Overtap the nuts to the minimum required for the fastener assembly and lubricate with a lubricant containing a visible dye.

Except as noted below, for ASTM A325 bolts, use nuts conforming to ASTM A563, Grades DH, DH3, C, C3, or D. For ASTM A490 bolts, use nuts conforming to ASTM A563, Grades DH or Grade DH3. Heat treat nuts to be galvanized to Grade DH. Lubricate galvanized nuts with a lubricant containing a visible dye.

Provide plain nuts with a minimum hardness of 89 HRB. Use only Grade C3 or Grade DH3 nuts with ASTM A325, Type 3 bolts. Use only Grade DH3 nuts with ASTM A490, Type 3 bolts.

Use washers conforming to ASTM F436.

717.02 Steel Forgings. Conform to AASHTO M 102, Classes C, D, F, and G.

717.03 Pins and Rollers. Furnish pins and rollers more than 9 inches (230 millimeters) in diameter from annealed carbon steel forgings conforming to AASHTO M 102, Class C.

Furnish pins and rollers 9 inches (230 millimeters) or less in diameter from either annealed carbon steel forgings conforming to AASHTO M 102, Class C or cold finished carbon steel shafting conforming to AASHTO M 169, Grade 1016 to Grade 1030 inclusive, with a minimum Rockwell Scale B hardness of 85. The hardness requirement may be waived if the steel develops a tensile strength of 70,000 pounds per square inch (480 megapascals) and a yield point of 36,000 pounds per square inch (250 megapascals).

For pin threads, conform to ANSI B1.1, *Unified Inch Screw Threads (UN and UNR Thread Form)*, Class 2A. Thread pin ends with a diameter of 1⅜ inches (35 millimeters) or more with 6 threads to the inch (25 millimeters).

717.04 Castings.

(a) Steel castings. Conform to AASHTO M 103, Grade 70-36 (485-250).

(b) Chromium alloy steel castings. Conform to AASHTO M 163, Grade CA15.

(c) Gray iron castings. Conform to AASHTO M 105, Class No. 30B, unless otherwise specified. Make the castings without pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting strength and value for the service intended. Boldly fillet the castings at angles and make the arrises sharp and perfect. Sand blast castings or otherwise effectively remove the scale and sand to present a smooth, clean, and uniform surface.

(d) Malleable iron castings. Conform to ASTM A47, Grade 35018, unless otherwise specified. For workmanship, finishing, and cleaning, conform to Subsection 717.04(c).

717.05 Welded Stud Shear Connectors. Conform to AASHTO M 169 and Article 11.3.3, *Welded Stud Shear Connectors* of AASHTO, *LRFD Bridge Construction Specification.*

717.06 Steel Pipe. Furnish galvanized steel pipe conforming to ASTM A53, Type F, standard weight class, and plain ends for the designation specified in the contract.

717.07 Galvanized Coatings. When specified, galvanize structural steel according to AASHTO M 111.

717.08 Sheet Lead. Furnish common desilverized lead conforming to ASTM B29. Furnish sheets in a uniform 0.125±0.030-inch (6±1-millimeter) thickness without cracks, seams, slivers, scale, and other defects.

717.09 Steel Grid Floors. Conform to ASTM D5484, Type I. Furnish galvanized steel grid floors unless painting is specified.

717.10 Bearings.

(a) Elastomeric bearings, plain or laminated. Conform to AASHTO M 251.

(b) High load rotational spherical bearings. Conform to ASTM D5977.

717.11 Polytetrafluoroethylene (PTFE) Surfaces for Bearings. When PTFE surfaces are specified for bearings, which are not listed in Subsection 717.10, conform to the following:

(a) PTFE resin. Furnish virgin PTFE resin material conforming to ASTM D4894 or ASTM D4895.

(b) Filler material. Furnish milled glass fibers, carbon, or other approved inert material.

(c) Adhesive material. Furnish epoxy resin adhesive conforming to AASHTO M 235.

(d) Unfilled PTFE sheet. Furnish unfilled PTFE sheet made from PTFE resin. Conform to Table 717-1.

(e) Filled PTFE sheet. Furnish filled PTFE sheet made from PTFE resin uniformly blended with filler material. Do not exceed 15 percent filler content using fiberglass or 25 percent filler content using carbon fibers. For filled PTFE sheets containing glass fibers or carbon, conform to Table 717-1.

(f) Fabric containing PTFE fibers. Furnish fabric made from oriented multifilament PTFE fluorocarbon and other fibers or from a mixture of PTFE fibers made from twisted, slit PTFE tape and other fibers as required by proprietary designs. Conform to Table 717-1.

Table 717-1
Polytetrafluoroethylene Sheeting

Property	ASTM Method	Sheet Unfilled	Sheet with 15% Glass Fibers	Sheet with 25% Carbon Fibers	Woven Fabric
Min. tensile strength	D638 or D2256	2,800 lb/in^2 (19 MPa)	2,000 lb/in^2 (14 MPa)	1,300 lb/in^2 (9 MPa)	24,000 lb/in^2 (165 MPa)
Min. elongation	"	200%	150%	75%	35%
Min. specific gravity	D792	2.16±0.03	2.20±0.03	2.10±0.03	–
Melting point	D4591	623±2 ºF (328±11 ºC)	621±18 ºF (327±10 ºC)	621±18 ºF (327±10 ºC)	–

(g) Interlocked bronze and filled PTFE components. Furnish a phosphor bronze plate conforming to ASTM B100 with an 0.010-inch (0.25-millimeter) thick porous bronze surface layer conforming to ASTM B103 into which is impregnated a lead-PTFE compound. Overlay the surface with compounded PTFE not less than 0.001 inches thick (25 micrometers).

(h) Lubricants. Use lubricants consisting of a combination of solids that do not react chemically or electrolytically with the PTFE and its mating surface and remain stable in the environmental conditions expected at the bridge site.

(i) Surface treatment. For epoxy bonding, factory treat one side of the PTFE sheet with a sodium naphthalene or sodium ammonia process.

(j) Stainless steel mating surface. Conform to ASTM A167, Type 304 or ASTM A240, Type 304 and the following:

(1) Thickness	0.0359 in (0.91 mm) min.
(2) Surface finish	8 µin root mean square max. (2 µm root mean square max.)

Polish or roll stainless steel mating surfaces as necessary to a finish no less than 20 micro-inches (5 µm).

717.12 Aluminum Alloy for Bridge Rail. Conform to AASHTO-AGC-ARTBA, *A Guide to Standardized Highway Barrier Hardware*.

717.13 Aluminum Bolt Heads and Nuts. Conform to American standard heavy hexagon ANSI B18.2. For threads, conform to American standard coarse series, Class 2 fit, ANSI specification B1.1, *Unified Inch Screw Threads (UN and UNR Thread Form)*.

717.14 Aluminum Welding Wire. Conform to Table 717-2.

Table 717-2
Aluminum Welding Wire

Alloys Series	Specification	Wire
3xxx and 6xxx	AWS A5.10	ER 4043
3xxx, 5xxx, and 6xxx		ER 5356
5xxx and 6xxx		ER 5556 or ER 5183

Section 718. — TRAFFIC SIGNING AND MARKING MATERIAL

718.01 Retroreflective Sheeting. Conform to ASTM D4956, including supplementary requirements.

718.02 Reserved.

718.03 Panels. Conform to the following:

(a) Plywood. Furnish exterior Grade B-B high-density overlay plywood or better conforming to NIST Product Standard PS 1, *Construction and Industrial Plywood*. Use ½-inch (13-millimeter) thick plywood for sign panels with a facial area 4 square feet (0.4 square meters) or less and the horizontal dimension no greater than the vertical dimension. Use ¾-inch (19-millimeter) thick plywood for larger panels.

(b) Steel. Furnish continuous coated (galvanized) 0.079-inch (2-millimeter) sheet steel blanks conforming to ASTM A653 and zinc coating designation G90.

Furnish panels with a substantially plane surface. Do not use twisted or buckled panels.

(c) Aluminum. Furnish panels conforming to ASTM B209, alloy 6061-T6 or 5052-H38.

Fabricate temporary panels and permanent panels smaller or equal to 30 by 30 inches (750 by 750 millimeters) from 0.080-inch (2-millimeter) thick aluminum sheets. Fabricate larger permanent panels from 0.125-inch (3-millimeter) thick aluminum sheets.

Furnish blanks without laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. Select blanks with uniform thickness and are commercially flat.

(d) Plastic.

(1) Non-reinforced plastic. Furnish polycarbonate material that is ultraviolet stabilized for outdoor weathering and will accept adhesives, coatings, and retroreflective sheeting material.

Fabricate panels smaller or equal to 24 by 24 inches (600 by 600 millimeters) from 0.08-inch (2-millimeter) thick plastic blanks. Fabricate larger panels from 0.125-inch (3-millimeter) thick plastic blanks.

Furnish panels that are flat and free of buckles, warps, and other defects. Do not allow a gap between adjacent panels greater than ⅝ inch (16 millimeters) where multiple panels adjoin. Attach reinforcement stiffeners on the back of panels larger than 24 by 24 inches (600 by 600 millimeters) for rigidity and mounting on supports.

(2) Reinforced plastic (fiberglass). Furnish panels made from fiberglass reinforced thermoset polyester acrylic modified laminate sheets. Furnish sign panels ultraviolet stabilized for outdoor weathering ability that will accept adhesives, coatings, and retroreflective sheeting material.

Furnish sign panels free of visible cracks, pinholes, foreign inclusions, or surface wrinkles that would affect implied performance, alter the specific dimensions of the panel, or otherwise affect the sign panels serviceability.

Fabricate fiberglass reinforced panels conforming to the following mechanical and physical properties:

(a) Average tensile strength, ASTM D638	10,000 psi (69 MPa) min.
(b) Average tensile modulus, ASTM D638	1,200,000 psi (8.3 GPa) min.
(c) Average flexural strength, ASTM D790	20,000 psi (140 MPa) min.
(d) Average flexural modulus, ASTM D790	1,200,000 psi (8.3 GPa) min.
(e) Average compression strength, ASTM D695	32,000 psi (220 MPa) min.
(f) Average compression modulus, ASTM D695	1,400,000 psi (9.7 GPa) min.
(g) Punch shear, ASTM D732	13,000 psi (90 MPa) min.
(h) Thickness	0.13±0.004 in (3.4±0.1 mm)
(i) Size, dimension less than 12 ft (3.6 m), ASTM D3841	±0.12 in (±3 mm)
(j) Squareness in 12-ft (3.6-m) length, ASTM D3841	±0.12 in (±3 mm)
(k) Surfaces, top and bottom	Smooth
(l) Color, visually uniform gray, Munsell color system	N7.5 to N8.5
(m) Coefficient of lineal thermal expansion, ASTM D696	0.000004 in/in/°F (0.1 μm/mm/°C) max.
(n) Flame resistance (extent of burning), ASTM D635	1 in (25 mm) max.
(o) Weather resistance, ASTM D3841	Grade 1 or 2

(e) Extruded aluminum. Furnish panels conforming to ASTM B221, aluminum alloy 6063-T6. Conform to Subsection 718.03(c) for panel thickness and fabrication. The maximum allowable deviation from flat on the face is 0.05 inches per foot (4 millimeters per meter).

718.04 Sign Posts. Furnish sign posts that are straight, smooth, and without defects affecting strength, durability, or appearance. Conform to the following:

(a) Wood. Furnish posts conforming to AASHTO M 168. Treat the posts according to Category 4A of the AWPA Standard U1-UC4A, *Ground Contact, General Use* for waterborne preservative treatments ACA, ACZA, or CCA.

(b) Galvanized metal. Conform to the following:

(1) U-channel steel. Furnish flanged, channel, galvanized steel posts conforming to ASTM A499, Grade 60 (420) and the following:

(a) Punching. Starting 1 inch (25 millimeters) from the top and extending the full length of the post, drill or punch ⅜-inch (10-millimeter) holes on 1-inch (25 millimeter) centers along the centerline of the bottom of the U. Remove burrs and sharp edges.

(b) Galvanizing after punching AASHTO M 111

(2) Square tubular steel. Furnish square tubular galvanized steel posts conforming to ASTM A1011, Grade 55 (380) and the following:

(a) Punching. Starting 1 inch (25 millimeters) from the top and extending the full length of the post, drill or punch $^{7}/_{16}$-inch (11-millimeter) holes on 1-inch (25-millimeter) centers along the centerline of all four sides, in true alignment and opposite each other directly and diagonally. Remove burrs and sharp edges.

(b) Galvanizing after punching ASTM A123 or ASTM B695

(c) Aluminum. Furnish standard shapes and thicknesses conforming to ASTM B221, alloy 6061-T6, 6351-T5, 6063-T6, or 6005-T5.

(d) Corrosion resistant steel. Furnish posts conforming to ASTM A588 or ASTM A242. Zinc-coat the embedded portion of the corrosion resistant steel post according to ASTM A123.

718.05 Object Marker and Delineator Posts. Conform to the following:

(a) Wood. Furnish 4- by 4-inch (100- by 100-millimeter) wooden posts conforming to Subsection 718.04(a).

(b) Steel. Furnish flanged U-channel steel posts weighing not less than 2 pounds per foot (3 kilograms per meter) and conforming to ASTM A36. Galvanize according to AASHTO M 111.

(c) Aluminum. Furnish standard shaped ⅛-inch (3-millimeter) thick aluminum posts conforming to ASTM B221, alloy 6063-T6.

(d) Plastic. Furnish flexible delineator posts made with high-impact resistant polymer material.

718.06 Hardware. Furnish galvanized steel or aluminum alloy lag screws, washers, clip angles, wood screws, shear plates, U-bolts, clamps, bolts, nuts, and other fasteners.

For high-strength steel bolts, nuts, and washers, conform to Subsection 717.01(e). Galvanize steel hardware according to AASHTO M 232.

For aluminum alloy bolts, nuts, and washers, conform to Subsections 717.12 and 717.13 as applicable.

For neoprene or nylon washers, furnish ⅛ inch (3.2 millimeters) thick by 1-inch (25 millimeters) minimum outside diameter with maximum allowable applied torque 480 inch-pounds (54 Newton-meters).

718.07 Legends and Borders. Use colors specified in plans or the MUTCD, *Standard Highway Signs, Including Pavement Marking Standard Alphabets* and material conforming to Subsection 718.01.

718.08 Delineator and Object Marker Retroreflectors. Furnish retroreflectors that are ready for mounting.

(a) Type 1 (acrylic plastic lens). Furnish an acrylic plastic lens with a minimum dimension of 3 inches (75 millimeters) with prismatic optical elements and a smooth, clear, transparent face. Fabricate the back from similar material and fuse it to the lens around the entire perimeter to form a homogenous unit. Seal the units against the intrusion of foreign material. Conform to Table 718-1 regardless of the orientation angle.

Table 718-1
Minimum Coefficient of (Retroreflective)
Luminous Intensity (R_I) (1)

Candelas per Foot-candle				
Observation Angle	**Entrance Angle**	**White(2)**	**Yellow**	**Red**
0.1°	0°	115	70	30
0.1°	20°	45	25	12
Candelas per Lux				
Observation Angle	**Entrance Angle**	**White(2)**	**Yellow**	**Red**
0.1°	0°	10.7	6.5	2.8
0.1°	20°	4.2	2.3	1.1

(1) See AASHTO T 257.
(2) Crystal, clear, or colorless are acceptable color designations.

Mount the retroreflector unit in a housing fabricated from 0.063-inch (1.6-millimeter) ASTM B209, aluminum alloy 3003-H-14 or similar, or from 0.064-inch (1.6-millimeter) cold rolled and hot dip galvanized steel. Furnish antitheft attachment hardware.

(b) Type 2 (retroreflective sheeting). Furnish a prismatic retroreflective sheeting with a minimum dimension of 3 inches (75 millimeters) and with a Class 1 or Class 2 adhesive backing conforming to Subsection 718.01. Attach the sheeting to an aluminum or plastic support panel (target plate) of the size and dimension specified.

718.09 Solventborne Traffic Paint. Conform to AASHTO M 248, Type N or Type F traffic paint.

Use volatile organic content (VOC) compliant solventborne paint with a VOC of 0.134 ounces per gallon (150 grams per liter) or less. Yellow pigment must be without lead, chrome, and other heavy metals as defined by the EPA.

718.10 Waterborne Traffic Paint. Furnish an acrylic water-based, ready-mixed paint conforming to the following:

(a) Composition. Furnish a paint composed of resin solids of 100 percent acrylic polymer with the exact formulation determined by the manufacturer. Conform to the following:

(1) Pigment, ASTM D3723 45 to 55 percent by mass

(2) Lead, chromium, cadmium, or cobalt ASTM D3335 & ASTM D3718	0 percent by mass
(3) Volatile organic compounds, EPA Method 24	20.0 oz/gallon (150 g/L) max.
(4) Density of paint, ASTM D1475	12.0 lb/gallon (1.44 kg/L) min.
(b) Viscosity. ASTM D562	75-90 Krebs units
(c) Drying time.	
(1) Dry to no pickup, ASTM D711	10 minutes max.
(2) Drying to no track, ASTM D713	90 seconds max.
(d) Flexibility. ASTM D522, using the ¼-in (6.4-mm) cylindrical mandrel	No cracking or flaking
(e) Dry opacity. ASTM D2805, contrast ratio at 319 ft^2/gallon (7.85 m^2/L) spreading rate	0.96 min.
(f) Color.	
(1) White, ASTM D1729	Match FHWA standard highway white
(2) Yellow, ASTM D1729	Match FHWA standard highway yellow
(g) Daylight reflectance. (Without glass beads)	
(1) White, ASTM E1347	84 percent relative to magnesium oxide standard
(2) Yellow, ASTM E1347	55 percent relative to magnesium oxide standard
(h) Bleeding ratio. ASTM D868. Determine reflectance according to ASTM D1347 immediately after drying. Divide the average of three reflectance readings of the paint over the bleeding surface by the average of three readings over the non-bleeding surface to determine the bleeding ratio	0.96 min.
(i) Freeze-thaw stability. ASTM D2243	±5 Krebs units max.

(j) Storage stability. During a 12-month storage period, conform to the following:

(1) No excessive setting, caking, or increase in viscosity; and

(2) Readily stirred to a consistency for use in the striping equipment.

718.11 Epoxy Markings. Furnish a 2-component, 100 percent solids type system for hot-spray application conforming to the following:

(a) Pigments. Component A. Percent by mass.

(1) White.	
(a) Titanium dioxide (TiO_2), ASTM D476, Type IV	18 percent min.
(b) Epoxy resin, ASTM D1652	75 to 82 percent
(2) Yellow:	
(a) Chrome yellow ($PbCrO_4$), ASTM D126	23 percent min.
(b) Epoxy resin, ASTM D1652	70 to 77 percent
(3) Non-Lead Yellow:	
(a) Titanium dioxide ($TiO_{2)}$ ASTM D476, Type II and Type III	14 percent min.
(b) Organic yellow	7 to 8 percent
(c) Epoxy resin, ASTM D1652	75 to 79 percent
(b) Epoxy content. Component A. Mass per epoxy equivalent, ASTM D1652	Manufacturer's target value ±50
(c) Amine value. Component B, ASTM D2074	Manufacturer's target value ±50
(d) Toxicity. Toxic or injurious fumes at application temperature	None

(e) Color. 15 mil (0.38 millimeter) film thickness specimen (cured).

(1) White, ASTM D1729	Match FHWA standard highway white
(2) Yellow, ASTM D1729	Match FHWA standard highway yellow

(f) Directional reflectance. (Without glass beads)

(1) White, ASTM E1347	84 percent relative to magnesium oxide standard
(2) Yellow, ASTM E1347	55 percent relative to magnesium oxide standard

(g) Drying time. 15-mil (0.38-millimeter) film thickness with glass beads (cured).

(1) Laboratory at 72 °F (22 °C), ASTM D711	30 minutes max. to no-pick-up condition
(2) Field at 77 °F (25 °C), viewed from 50 ft (15 m), ASTM D713	10 minutes max. to no-tracking condition
(h) Abrasion resistance. Wear index with a CS-17 wheel under a 35.3 oz (1000 g) load for 1000 cycles, ASTM D4060	82 max.
(i) Hardness. Type D hardness with 72-hour cure at 72 °F (22 °C), ASTM D2240	75 to 100

718.12 Thermoplastic Markings. Conform to AASHTO M 249.

718.13 Preformed Pavement Marking Tape. Conform to ASTM D4505, Reflectivity Level I; Class 1, 2, or 3; Skid Resistance Level A or B.

718.14 Glass Beads. Conform to AASHTO M 247 for the type specified. Treat glass beads with an adherence coating as recommended by manufacturer.

718.15 Pavement Markers.

(a) Non-plowable, extended life, retroreflective, pavement markers. Conform to ASTM D4280.

(b) Plowable, retroreflective, pavement markers. Conform to ASTM D4383.

(c) Non-reflective pavement markers. Furnish ceramic, plastic, or thermoplastic markers that are 4±⅛ inch (100±3 millimeters) in diameter at the base, $^{11}/_{16}\pm^{1}/_{16}$ inch (17.5±1.6 millimeters) in height, and where the base of the marker does not deviate from a flat plane by more than $^{1}/_{16}$ inch (1.6 millimeters).

Furnish markers of uniform composition, without surface irregularities, cracks, checks, chipping, peeling, spalling, crazing, and other physical damage interfering with appearance, application, or durability. Furnish precast markers in the form of a single based spheroidal segment terminating in a rounded or squared shoulder.

718.16 Temporary Pavement Markings.

(a) Preformed retroreflective tape. Furnish 4-inch (100-millimeter) wide tape conforming to ASTM D4592, Type I (removable).

(b) Pavement markers. Furnish temporary pavement markers conforming to ASTM D4280 or flexible pavement markers not exceeding approximately 2 inches (50 millimeters) high, with retroreflective tape on both faces of the vertical section, capable of retroreflecting light from opposite directions, and with an adhesive on the base.

(c) Traffic paint. Conform to Subsections 718.09 or 718.10.

718.17 Epoxy Resin Adhesives. Furnish epoxy resin adhesives conforming to AASHTO M 237 for bonding traffic markers to rigid and asphalt concrete pavements.

Section 719. — PAINT

719.01 General. Furnish a contrasting color for each coat of paint. For the finish coat color, conform to FED-STD 595 B. If requested, provide color chips from the paint supplier.

(a) Packaging. Furnish paint in strong, substantial containers, plainly marked with the following:

(1) Trade name or trade mark;

(2) Paint type, color, formulation, lot number, and date of manufacture;

(3) Net mass;

(4) Volume including the percent of solids and the percent of volatile organic compound (VOC);

(5) Storage requirements and shelf life;

(6) Mixing instructions and equipment cleanup instructions; and

(7) Name and address of the manufacturer.

(b) Volatile organic compound (VOC) content. Conform to the following VOC limits for both shop and field painting:

(1) Clear (unpigmented) coatings	3.7 lb/gallon (450 g/L) max.
(2) Other coatings	2.9 lb/gallon (350 g/L) max.
(c) Lead content.	None

(d) Other properties. Furnish paint that:

(1) Does not show excessive settling in a freshly opened full container;

(2) Easily redisperses with a paddle to a smooth, homogeneous state free of curdling, livering, caking, color separation, lumps, and skins;

(3) Does not skin within 48 hours in a three-quarter filled, closed container;

(4) Brushes on easily;

(5) Possess good leveling properties;

(6) Shows no running or sagging tendencies when applied to smooth steel vertical surfaces;

(7) Dries to a smooth uniform finish, without roughness, grit, unevenness and other surface imperfections;

(8) Shows no streaking or separation when flowed on clean glass; and

(9) Shows no thickening, curdling, gelling, or hard caking after 6 months of storage in a full, tightly covered container at a temperature of 70 ºF (20 ºC).

719.02 Paint for Timber Structures.

(a) Primer. Conform to MPI numbers 5 or 6.

(b) Paint. Conform to MPI numbers 5 or 6.

719.03 Paint for Masonry Block Structures. Conform to MPI numbers 4, 10, or 11. Color tint with universal or all-purpose concentrates.

719.04 Paint for Steel Structures. Conform to the following:

(a) Zinc rich coating	SSPC no. 20
(b) White or colored silicone alkyd paint	SSPC no. 21
(c) Epoxy polyamide paint	SSPC no. 22
(d) Latex primer for steel structures	SSPC no. 23
(e) Latex semigloss exterior topcoat	SSPC no. 24
(f) Zinc-oxide, alkyd, linseed oil primer	SSPC no. 25
(g) Aliphatic polyurethane topcoat	SSPC no. 36
(h) Moisture-cured polyurethane	SSPC no. 38
(i) Zinc-rich moisture-cured polyurethane primer	SSPC no. 40
(j) Moisture-cured polyurethane primer	SSPC no. 41
(k) White or tinted alkyd paint	SSPC no. 104

719.05 Paint for Concrete Structures. Conform to the following:

(a) Epoxy low gloss paint	MPI 108
(b) Epoxy semi-gloss paint	MPI 177

719.06 Paint for Aluminum Structures. Conform to the following:

(a) Metal Primer	MPI 95
(b) Light Industrial Coating, Exterior, Water-Based	MPI 161, 163, or 164

719.07 Paint for Other Metal Structures. Conform to the following:

(a) Metal Primer, galvanized surfaces	SSPC no. 27
(b) Exterior Latex	MPI 5
(c) Alkyd/Oil	MPI 6

719.08 Penetrating Stain. Conform to the following:

(a) Weatherometer on base material, ASTM G152 or ASTM G153	1000 hours
(b) Acrylic dispersion	73.4 percent of nonvolatile solvent
(c) Viscosity, ASTM D562	58±2 Krebs units
(d) Solids volatile content	40.3 percent by mass

Store stain according to the manufacturer's recommendations.

719.09 Mineral Spirits (Petroleum Spirits). Conform to ASTM D235.

Section 720. — STRUCTURAL WALL AND STABILIZED EMBANKMENT MATERIAL

720.01 Mechanically-Stabilized Earth Wall Material.

(a) Concrete face panels. Conform to Section 552 and the following:

(1) Use concrete Class A(AE) according to Section 552.

(2) Conform to Section 562 and fully support the units until the concrete reaches a minimum compressive strength of 1,000 pounds per square inch (7 megapascals). The units may be shipped and installed after the concrete reaches a minimum compressive strength of 3,400 pounds per square inch (24 megapascals).

(3) Finish the front face of the panel with a Class 1 finish according to Subsection 552.16. Screed the rear face of the panel to eliminate open pockets of aggregate and surface distortions in excess of ¼ inch (6 millimeters). Cast the panels on a flat area. Do not attach galvanized connecting devices or fasteners to the face panel reinforcement steel.

(4) Clearly scribe on an unexposed face of each panel the date of manufacture, the production lot number, and the piece mark.

(5) Handle, store, and ship units so as to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Support panels in storage on firm blocking to protect the panel connection devices and the exposed exterior finish.

(6) Manufacture units within the following tolerances:

(a) Panel dimensions. Position of panel connection devices within 1 inch (25 millimeters). All other dimensions within $^{3}/_{16}$ inch (5 millimeters).

(b) Panel squareness. Do not exceed ½ inch (13 millimeters) as determined by the difference between the two diagonals.

(c) Panel surface finish. Do not exceed ⅛ inch (3 millimeters) for surface defects on smooth formed surfaces of 5 feet (1.5 meters) or more in length. Do not exceed $^{5}/_{16}$ inch (8 millimeters) for surface defects on textured-finished surfaces of 5 feet (1.5 meters) or more in length.

Concrete face panels having the following defects will be rejected.

- Defects that indicate imperfect molding;
- Defects indicating honeycombed or open texture concrete;
- Cracked or severely chipped panels; or
- Color variation on front face of panel.

(b) Wire facing. Fabricate from welded wire fabric conforming to AASHTO M 55, except that Subsection 7.4. applies for longitudinal and transverse wire sizes. Galvanize according to AASHTO M 111, Coating Grade 85 after fabrication.

(c) Backing mat. Fabricate from welded wire fabric conforming to AASHTO M 55, except that Subsection 7.4 applies for longitudinal and transverse wire sizes. Galvanize according to AASHTO M 111, Coating Grade 85 after fabrication.

(d) Clevis connector. Fabricate from cold-drawn steel wire conforming to AASHTO M 32 and weld according to AASHTO M 55. Galvanize according to AASHTO M 111, Coating Grade 85 after fabrication.

(e) Connector bars. Fabricate from cold-drawn steel wire conforming to AASHTO M 32. Galvanize according to AASHTO M 111, Coating Grade 85.

(f) Fasteners. Furnish ½-inch (13-millimeter) diameter, heavy hexhead bolts, nuts, and washers conforming to ASTM A325. Galvanize according to AASHTO M 232.

(g) Hardware cloth. Fabricate with maximum ¼-inch (7-millimeter) square mesh openings from woven or welded galvanized steel wire fabric conforming to ASTM A740.

(h) Reinforcing mesh. Fabricate from cold-drawn steel wire conforming to AASHTO M 32. Weld the wire into the finished mesh fabric according to AASHTO M 55. Galvanize according to AASHTO M 111, Coating Grade 85 after fabrication. Repair damage to the galvanized coating before installation.

(i) Reinforcing strips. Fabricate from high-strength, low-alloy structural steel conforming to ASTM A572, Grade 65 (450), Type 3. Galvanize according to AASHTO M 111, Coating Grade 85 after fabrication.

(j) Tie strip. Fabricate from hot-rolled steel conforming to ASTM A1011, Grade 50. Galvanize according to AASHTO M 111, Coating Grade 85.

720.02 Gabion and Revet Mattress Material. Fabricate gabion baskets 12 inches (300 millimeters) or greater in vertical dimension and revet mattresses less than 12 inches (300 millimeters) in vertical dimension from either welded wire mesh or twisted wire mesh. Conform to the following:

(a) Welded wire mesh	ASTM A974
(b) Twisted wire mesh	ASTM A975

Section 721. — ELECTRICAL AND ILLUMINATION MATERIAL

721.01 Electrical Material. Conform to the following:

(a) Conduit. Conform to the following:

(1) Nonmetallic conduit and duct couplings, elbows, bends, and nipples. For above ground and underground use without concrete encasement, furnish rigid PVC, heavy wall conduit conforming to UL 651, *Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings*. Conform to ASTM D2564 for solvent cement to join conduit.

(2) Metallic conduit and duct, couplings, elbows, bends, and nipples. Furnish rigid galvanized steel conduit conforming to UL 6, *Electrical Rigid Metal Conduit - Steel*. Uniformly coat the conduit on the outside with an asphalt mastic conforming to AASHTO M 243 or a 20-mil (0.5-millimeter) PVC coating. Furnish rigid, full-mass sherardized or galvanized threaded fittings.

(3) Flexible conduit. Furnish a watertight metallic conduit conforming to UL 360, *Liquid-Tight Flexible Metal Conduit* acceptable for equipment grounding. Furnish insulated throat, grounding, malleable iron watertight fittings.

(4) Conduit bodies, boxes, and fittings. Furnish watertight, galvanized steel conforming to UL 514B, *Conduit, Tubing, and Cable Fittings*.

(b) Pull boxes, frames, and covers. For boxes formed in concrete, fabricate with cast iron or welded sheet steel having a minimum thickness of 0.188 inches (5 millimeters). Galvanize, inside and out, according to AASHTO M 232.

(c) Wire and cable.

(1) Lighting. Furnish either ozone resistant cross-linked polyethylene (XLP) or polyvinyl chloride (PVC) insulated cable, with or without a nylon jacket conforming to the following:

(a) Polyethylene (XLP). Insulated Cable Engineers Association (ICEA) S-66-524, ICEA S-95-658/NEMA WC70, *Non-Shielded Power Cables Rated 2000 V or Less*, ICEA S-96-659/NEMA WC71, *Non-Shielded Power Cables Rated 2001-5000 V*, ICEA S-93-639/NEMA WC74, *Shielded Power Cable 5,000-46,000 V*; or

(b) Polyvinyl chloride (PVC). Conform to UL 83, *Thermoplastic-Insulated Wires and Cables*.

(2) Electrical. Furnish soft drawn or annealed copper conductors conforming to ASTM B3 and stranding conforming to ASTM B8.

Furnish 7 strand for #10 AWG through #2 AWG (5.3 square millimeters through 33.6 square millimeters), and 17 strand for #1 AWG through #4/0 AWG (42.4 square millimeters through 107 square millimeters). Furnish #6 AWG (13.3 square millimeters) minimum solid copper ground wires.

(d) Circuit breakers and panels. Conform to UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures* and UL 67, *Panelboards*. Furnish molded case thermal magnetic trip type breakers. Furnish panel enclosures conforming to NEMA 250, *Enclosures for Electrical Equipment (1,000 V Maximum)*, Type 3R, lockable with padlocks.

(e) Safety disconnect switches. Furnish heavy duty, NEMA 250, *Enclosures for Electrical Equipment (1,000 V Maximum)*, Type 3R, safety disconnect switches conforming to UL 98, *Enclosed and Dead-Front Switches*.

(f) Grounding and bonding equipment. Furnish ⅝-inch (16-millimeter) diameter, 8-foot (2.5-meter) long, copper-clad steel ground rods, ground clamps, grounding and bonding bushings, and lock nuts conforming to UL 467, *Grounding and Bonding Equipment*.

(g) Contactors and control transformers. Furnish a magnetic 60-ampere, two-pole contactor with a 120-volt coil, equipped with control switches for automatic actuation conforming to UL 508, *Industrial Control Equipment*. Furnish cadmium-sulfide type photocell controls for 120 or 240-volt operation as applicable; rated at 1000 watts resistive load or 1800 volt-amperes inductive load; adaptable for pole-top mounting in a plug-in, locking-type receptacle conforming to UL 773, *Plug-In Locking Type Photocontrols for Use with Area Lighting* and with a built-in surge protective device for protection from induced high-voltage and follow-through currents.

Furnish single-phase, 240/480 volt primary, 120/240 volt secondary, dry type, 60 hertz, 1 KVA transformers for indoor or outdoor use, conforming to UL 506, *Specialty Transformers*.

(h) Secondary lightning arrester. Furnish a secondary lightning arrester rated for a maximum operating voltage of 650 volts RMS with a bracket for mounting on the control cabinet backboard.

(i) Service poles. Furnish treated southern yellow pine, treated Douglas fir, butt-treated western red cedar, or butt-treated northern white cedar service poles that are at least 30 feet (9 meters) long. Treat the poles according to Subsection 716.03.

(j) Meter cabinet. Conform to local power company requirements.

(k) Control enclosure. Furnish a NEMA 250, *Enclosures for Electrical Equipment (1,000 V Maximum)*, Type 3R, equipped with door clamps on the unhinged sides, solid neoprene gasket, welded seams, continuous hinge with stainless steel pin, stainless steel external hardware, backboard for mounting apparatus, padlock with an outdoor, tumbler-type padlocks keyed the same, and supplied with 2 keys for each lock. Furnish a cabinet constructed of one of the following:

(1) Code-gauge stainless steel conforming to ASTM A167; or

(2) Code-gauge aluminum sheet with mechanical properties equivalent or exceeding ASTM B209, alloy 5052-H32.

721.02 Lighting Material. Conform to the following:

(a) Poles. Furnish 11 gage (3-millimeter thick) round steel conforming to ASTM A595 or aluminum shafts conforming to ASTM B429, alloy 6063-T6, tapered uniformly at 0.14 inches per foot (12 millimeters per meter). Provide hand holes with no rough edges and a reinforcing frame and cover designed to maintain the required pole strength. Weld a 2.375- to 3.0-inch (60- to 75-millimeter) outside diameter vertical tenon, fabricated from the same material as the pole, and welded at the top and on the same axis as the pole.

Furnish pole sections in minimum 15-foot (4.5-meter) lengths. Furnish pole sections less than 70 feet (21 meters) in height in two sections or less; between 70 and 100 feet (21 and 30 meters) in three sections or less; and over 100 feet (30 meters) in four sections or less.

Design and furnish poles capable of sustaining the following loadings:

(1) A horizontal load of 500 pounds (2.2 kilonewtons) applied 18 inches (450 millimeters) from the shaft top, in any direction, without failure of any component part, and a maximum allowable vertical deflection of 7.5 percent of the shaft length.

(2) A horizontal load of 50 pounds (220 newtons) applied at the luminaire attachment point and normal to the pole bracket member plane, with a vertical load of 30 pounds (130 newtons) on the luminaire supporting arm, and a maximum allowable horizontal deflection of 10 percent of the luminaire supporting arm's horizontal length.

(3) A vertical load of 100 pounds (440 newtons) applied at the luminaire attachment point, and a maximum allowable vertical deflection of 5.5 percent of the pole arm's horizontal length.

(4) A vertical load of 250 pounds (1.1 kilonewtons) applied at the luminaire attachment point, and no collapse or rupture of any portion of the structure.

(5) The pole arm and luminaire mass with a maximum allowable deflection from vertical at the top of the pole of 1 percent of the total shaft length.

Prime the poles inside and out according to the fabricator's recommendation. Use epoxy modified enamel matching FED-STD 595 color 27040 for the finish coat.

(b) Pole arms.

(1) Material. Furnish steel or aluminum. Use the same material as the pole.

(2) Type. Furnish bracket type, truss or single member arms. Furnish single member arms with a minimum diameter of 2 inches (50 millimeters) and the same taper as the pole.

(3) Connection. Furnish a weather resistant connection to the pole and a smooth raceway for wiring. Furnish fittings for connection to the pole.

(c) Anchor bases. Furnish a one-piece base dimensioned for adequate pole mounting and structural support with holes for anchor bolts and tapped holes for anchor bolt covers. Fabricate anchor bases from material similar to the pole material and conform to the following:

(1) Steel casings	AASHTO M 103, Grade 65-35 (450-240)
(2) Steel plate	ASTM A36
(3) Aluminum castings	ASTM B26

(d) Bolts, nuts, and washers.

(1) Steel anchor bolts. Conform to ASTM A36, except as amended by *(a)* or *(b)* below:

(a) (1) Yield strength	55 kips/in^2 (380 MPa) min.
(2) Tensile strength	75 to 95 kips/in^2 (520 to 650 MPa)
(3) Elongation in 8 in (200 mm)	18 percent min.
(4) Elongation in 2 in (50 mm)	21 percent min.

(5) Area reduction	30 percent min.
(b) (1) Yield strength	105 kips/in^2 (725 MPa) min.
(2) Tensile strength	100 to 150 kips/in^2 (680 to 1030 MPa)
(3) Elongation in 2 in (50 mm)	15 percent min.
(4) Area reduction	45 percent min.

(2) Hex head bolts. Conform to the following:

(a) 55 kips/in^2 (380 MPa) yield anchor bolts	ASTM A325
(b) 105 kips/in^2 inch (725 MPa) yield anchor bolts	ASTM A354, Grade BC

(3) Nuts. Conform to ASTM A563. Furnish nuts appropriate for the strength of the anchor bolt.

(4) Washers. Furnish flat, circular washers conforming to ASTM F436.

Galvanize the top 12 inches (300 millimeters) of anchor bolts and associated hardware according to AASHTO M 232.

(e) Anchor bolt covers. Furnish a bolt cover for each anchor bolt and ¼-inch (6-millimeter) stainless steel, Phillips-head or hex-head screws to attach the cover to the base or pole.

(f) Luminaries. Operate luminaries on a 240-volt series circuit. Furnish the following types of luminaires:

(1) Conventional highway luminaires. Furnish material for a complete installation including:

(a) Aluminum housings with refractor holder and slipfitter;

(b) Thermal shock-resistant glass prismatic refractors with gaskets and clips;

(c) Aluminum detachable reflectors with ethylene propylene terpolymer gaskets; and

(d) Internal regulator or auto regulator type ballast, with a power factor greater than 90 percent that will start lamps at a minimum ambient temperature of -20 °F (-29 °C).

Comply with ANSI specifications.

(2) Sign lighting luminaries. Furnish material for a complete installation including:

(a) Die-cast aluminum housings with mounting bracket and door assembly;

(b) Thermal, shock-resistant, borosilicate glass refractors with gaskets;

(c) Aluminum reflectors; and

(d) 120/240 volt, 60 hertz constant-wattage ballasts with a power factor greater than 90 percent that will start lamps at a minimum ambient temperature of -20 °F (-29 °C).

Section 722. — ANCHOR MATERIAL

722.01 Anchorage Devices. For post-tensioning, furnish anchorage devices capable of holding the prestressing steel at a load producing a stress of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.

Use a steel distribution plate or assembly to effectively distribute the compressive stresses from the anchoring device to the concrete. If the anchorage device is sufficiently large and is used with a steel grillage embedded in the concrete, the distribution plate or assembly may be omitted. Conform to the following:

(a) Do not exceed 3,000 pounds per square inch (21 megapascals) for the final unit compressive stress on the concrete directly beneath the plate or assembly.

(b) Do not allow bending stresses induced by prestressing to exceed the yield point of the material in the plates or assemblies, or cause visible distortion in the anchorage plate when 100 percent of the nominal load is applied.

722.02 Anchor Tendons. Furnish material conforming to the following:

(a) Prestressing steel. Conform to one of the following:

(1) Wire, uncoated stress-relieved for prestressed concrete	ASTM A421
(2) Steel strand, uncoated seven-wire stress-relieved for prestressed concrete	AASHTO M 203
(3) Steel strand, uncoated, seven-wire, compacted, stress-relieved for prestressed concrete	ASTM A779
(4) Uncoated high-strength steel bar for prestressed concrete	AASHTO M 275

(b) Couplers. Supply couplers that are capable of developing 95 percent of the minimum specified ultimate tensile strength of the tendon.

(c) Sheathing. Conform to one of the following:

(1) Free-stressing length.

(a) Polyethylene plastic tubing. Conform to ASTM D1248, Types II, III, or IV with a minimum wall thickness of 60 mils (1.5 millimeters).

(b) Hot-melt extruded polypropylene tubing. Conform to ASTM D4101, cell classification PP 210 B5554211 with a minimum wall thickness of 60 mils (1.5 millimeters).

(c) Hot-melt extruded polyethylene tubing. Conform to ASTM D3350 and ASTM D1248 Type III high-density with a minimum wall thickness of 60 mils (1.5 millimeters).

(d) Steel tubing. Conform to ASTM A500 with a minimum wall thickness of 0.20 inches (5 millimeters).

(e) Steel pipe. Conform to ASTM A53, Schedule 40 minimum.

(f) Plastic pipe. Conform to ASTM D1785, Schedule 40 minimum.

(2) Bonded length.

(a) High-density corrugated polyethylene tubing. Conform to AASHTO M 252 with a minimum wall thickness of 30 mils (0.75 millimeters).

(b) Corrugated, polyvinyl chloride tubes. Conform to ASTM D1784, Class 13464-B.

(c) Fusion-bonded epoxy. Conform to ASTM A775 with a minimum film thickness of 15 mils (0.4 millimeters).

(d) Corrosion inhibiting compounds. Use grease conforming to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

(e) Centralizers and spacers. Fabricate centralizers and spacers from material, except wood, that are not deleterious to the prestressing steel.

(f) Anchorages. Furnish material conforming to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

For strand tendons, supply anchorages that permit lift-off testing without the jack engaging the strand.

Furnish steel plates conforming to ASTM A36 or ASTM A588 for bearing plates. Provide grout tube holes in the bearing plates.

722.03 Rock Bolts. Furnish deformed bars (tendon), bearing plates, washer, nuts, and other accessories for tendons conforming to ASTM F432 and as follows:

(a) Tendon. Furnish hollow core bars conforming to ASTM A615. Use minimum Grade 75 (520) steel.

(b) Coupler. Supply couplers that are capable of developing 95 percent of the minimum specified ultimate tensile strength of the tendon.

(c) Bearing plate. Furnish bearing plates with grout tube holes.

(d) Corrosion inhibiting compounds. Use grease conforming to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

(e) Centralizers and spacers. Fabricate centralizers and spacers from any type of material, except wood, that is not deleterious to the tendon.

(f) Corrosion protection. Furnish steel with either fushion bonded epoxy coating or hot dip galvanizing for corrosion protection. Use fusion bonded epoxy coating conforming to ASTM A775 with a minimum film thickness of 15 mils (0.4 millimeters). Use hot dip galvanizing conforming to ASTM A153 with a minimum thickness of 3.9 mils (0.1 millimeters).

722.04 Soil Nails.

(a) Tendon. Furnish deformed bars conforming to one of the following:

(1) Deformed bars, Grade 60 (420) or Grade 75 (520)	ASTM A615
(2) Deformed bars, Grade 150 (1035)	ASTM A722

Provide new, straight, continuous, undamaged, bare, epoxy-coated, or encapsulated bars.

(b) Coupler. Furnish couplers that are capable of developing the full, ultimate tensile strength of the tendon as certified by the manufacturer.

(c) Fusion bonded epoxy coating. Apply epoxy coating conforming to ASTM A775, with the exception of the bend test requirements. Electrostatically apply the coating to a minimum thickness of 12 mils (0.3 millimeters). The coating at the wall anchorage end of epoxy-coated bars may be omitted over the length provided for threading the nut against the bearing plate.

(d) Encapsulation. Furnish corrugated polyethylene pipe conforming to AASHTO M 252 or corrugated polyvinyl chloride pipe conforming to ASTM D1784, Class 13464.

Section 723. — RESERVED

Section 724. — RESERVED

Section 725. — MISCELLANEOUS MATERIAL

725.01 Water. Conform to the following:

(a) Water for mixing or curing cement concrete, mortar, or grout. Conform to AASHTO M 157. Potable water of known quality may be used without testing according to AASHTO T 26. Potable water is safe for human consumption as defined by the public health authority having jurisdiction.

(b) Water for planting or care of vegetation. Furnish water that is free of substances injurious to plant life (such as oils, acids, alkalies, or salts).

(c) Water for earthwork, pavement courses, dust control, and incidental construction. Furnish water free of substances detrimental to the work.

725.02 Calcium Chloride, Magnesium Chloride, and Lignosulfonate.

(a) Calcium chloride liquid. Furnish a water solution conforming to the following:

(1) Calcium chloride liquid	AASHTO M 144, Type L
(2) Calcium chloride by mass	35 percent min.

(b) Calcium chloride flake. Conform to AASHTO M 144, Type S, Grades 1, 2, or 3, Class A.

(c) Magnesium chloride liquid. Furnish a water solution conforming to the following:

(1) Magnesium chloride by mass	28 percent min.
(2) Specific gravity, ASTM D1298	1.29 to 1.33

(d) Lignosulfonate liquid. Furnish a water solution with a base cation of ammonia, calcium, or sodium. Conform to the following:

(1) Dry solids [(1)]	50 percent
(2) Specific gravity, ASTM D1475	1.20 min.
(3) pH, ASTM E70	3.0 to 8.0

Note (1) Use Pulp and Paper Technical Association of Canada standard test Method H.1, *Determination of Solids Content of Pulp and Paper Mill Effluents*.

725.03 Lime.

(a) Lime for masonry. Conform to ASTM C207, Type NA.

(b) Lime for soil stabilization. Conform to AASHTO M 216.

(c) Lime for asphalt mixtures. Conform to AASHTO M 303.

725.04 Pozzolans.

(a) Fly ash. Conform to AASHTO M 295, Class C or Class F. When used to mitigate alkali-silica reactivity, also available alkalies as equivalent Na_2O	1.5 percent max.
(b) Ground granulated blast-furnace slag. Conform to AASHTO M 302, Grade 100 or Grade 120. When used to mitigate alkali-silica reactivity, also total alkalies as equivalent Na_2O	1.0 percent max.
(c) Silica fume (microsilica). Conform to AASHTO M 307. When used to mitigate alkali-silica reactivity, also total alkalies as equivalent Na_2O	1.0 percent max.

725.05 Mineral Filler. Conform to AASHTO M 17.

725.06 Concrete Building Brick. Conform to ASTM C55, normal weight.

725.07 Concrete Masonry Units. Conform to one of the following:

(a) Loadbearing concrete masonry units	ASTM C90, normal weight
(b) Concrete masonry units for constructing catch basins and manholes	ASTM C139
(c) Nonloadbearing concrete masonry units	ASTM C129, normal weight

725.08 Paving Brick. Conform to one of the following:

(a) Pedestrian and light traffic paving brick	ASTM C902, Class SX, Type I
(b) Heavy vehicular paving brick	ASTM C1272, Type F, Application PS

725.09 Precast Concrete Units and Accessories. Conform to the following:

(a) Precast reinforced concrete manhole sections	AASHTO M 199
(b) Precast concrete barrier	ASTM C825
(c) Concrete grid paving units	ASTM C1319
(d) Underground precast concrete utility structures	ASTM C858
(e) Precast concrete water and wastewater structures	ASTM C913
(f) Solid concrete interlocking paving units	ASTM C936

(g) Other precast concrete units and accessories	Section 601

725.10 Frames, Grates, Covers, and Ladder Rungs. Fabricate metal grates and covers to evenly bear on the frames. Correct bearing inaccuracies by machining. Assemble units before shipment. Mark pieces to facilitate reassembly at the installation site. Uniformly coat castings with a commercial preservative according to the manufacturer's standard practice. Conform to the following:

(a) Gray iron castings	AASHTO M 105
(b) Carbon steel castings	AASHTO M 103
(c) Structural steel	ASTM A36
(d) Galvanizing	AASHTO M 111
(e) Malleable iron castings	ASTM A47
(f) Aluminum alloy ladder rung material	ASTM B221, alloy 6061-T6
(g) Aluminum castings	ASTM B26, alloy 356.0-T6

725.11 Corrugated Metal Units. Conform to AASHTO M 36 for steel corrugated units. Conform to AASHTO M 196 for aluminum corrugated units. For coatings, conform to the following:

(a) Bituminous-coated corrugated units	AASHTO M 190, Type A
(b) Polymer-precoated corrugated units	AASHTO M 245, Grade 250/250

725.12 Plastic Lining. Furnish a film or fabric that is serviceable for the duration of the installation.

725.13 Grout.

(a) Neat hydraulic cement grout.

(1) Ground anchors, micropiles, and soil nails. Furnish a pumpable mixture of portland cement, sand, water, and admixtures. Use Type II portland cement conforming to AASHTO M 85. Furnish sand according to Subsection 703.01. Furnish water according to Subsection 725.01(a). Provide the minimum water content necessary for placement and a maximum water/cementitious material ratio of 0.45 by mass.

Chemical admixtures that control bleed or retard set may be used provided the additives conform to Subsection 711.03 and are mixed according to the manufacturer's recommendations. Do not use admixtures containing more than trace (from impurities, not as an intended constituent) quantities of chlorides, fluorides, aluminum, zinc, or nitrates.

The maximum water-soluble chloride ion (Cl^-) content of the grout is 0.06 percent Cl^- by mass of cement when tested according to ASTM C1218.

Furnish grout conforming to the following minimum compressive strengths:

(a) Ground anchors	3,500 lb/in^2 (25 MPa) at 7 days
(b) Micropiles	2,500 lb/in^2 (17.5 MPa) at 7 days and 5,000 lb/in^2 (35 MPa) at 28 days
(c) Soil nails	1,500 lb/in^2 (10.5 MPa) in 3 days and 3,000 lb/in^2 (21 MPa) in 28 days

(2) Miscellaneous applications. Furnish a grout consisting of a mixture of hydraulic cement, water, and admixtures. Do not exceed a water/cementitious material ratio of 0.44. Do not exceed 20 percent of the cement by mass if fly ash is used. Admixtures to reduce water content, improve the flowability, control bleeding, or control shrinkage may be added according to the manufacturer's recommendations. Furnish admixtures free of chlorides, fluorides, sulphites, and nitrates.

(b) Nonshrink grout. Conform to ASTM C1107. Provide a minimum compressive strength of 5,000 pounds per square inch (35 megapascals) in 3 days.

(c) Grout for post-tensioned structures. Conform to the requirements of the PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

(d) Polyester resin grout. Furnish polyester resin grout with a minimum ultimate compressive strength of 14,000 pounds per square inch (97 megapascals), a minimum ultimate tensile strength of 2,500 pounds per square inch (17 megapascals), and a minimum ultimate shear strength of 4,500 pounds per square inch (31 megapascals) when fully cured. Conform to ASTM F432, except where noted.

Furnish polyester resin grout consisting of an unsaturated polyester resin, evenly filled with nonreactive, inorganic aggregate of suitable size, and a separated catalyst filled with nonreactive inorganic filler. Supply resin in cartridge form. Provide cartridge lengths and diameters according to the manufacturer recommendations for the specified drill hole and reinforcing bar size. Provide resin cartridges readily and individually identified as to their respective gel times.

725.14 Polymer Concrete and Mortar. Furnish a polymer binder and fine aggregate in the proportions recommended by the polymer manufacturer with a minimum compressive strength of 3,500 pounds per square inch (25 megapascals) in 4 hours. Conform to the following:

(a) Epoxy mortar. Conform to ACI 503.4.

(b) Other polymer concrete or mortar. Conform to ASTM C1438, Type II.

725.15 Color Coating. Furnish a semi-opaque colored toner containing methyl methacrylate-ethyl acrylate copolymer resins or equivalent resins, solvents, and color-toning pigments suspended in solution by a chemical suspension agent. Provide color-toning pigments consisting of laminar silicates, titanium dioxide, and inorganic oxides. Conform to the following:

(a) Mass per liter, ASTM D1475	8.3 lb (38 kg) min.
(b) Solids by mass, ASTM D2369	30 percent min.

(c) Solids by volume	21 percent min.
(d) Drying time, ASTM D1640	30 minutes at 70 °F (21 °C) and 50 percent max. humidity
(e) Color change, ASTM D822, 1000 hours	No appreciable change
(f) Resistance to acids, alkalies, gasoline, and mineral spirits, ASTM D543	Excellent
(g) Water vapor transmission from interior concrete, ASTM D1653	Transmittable
(h) Oxidation over time	None

725.16 Slurry (Drilling Fluids).

(a) Mineral slurry. Furnish sodium bentonite or attapulgite in potable water. Use a mineral grain size that remains in suspension with sufficient viscosity and gel characteristics to transport drilled material out of the hole.

(b) Polymer slurry. Furnish a slurry compatible with soil type and water chemistry.

725.17 Reinforcing Fibers.

(a) Fibers for shotcrete. Use deformed steel or fibrillated polyolefin fibers conforming to ASTM A820 or ASTM D7508.

(b) Fibers for concrete. Use fully oriented, collated, fibrillated, white, ¾-inch (19-millimeter) long fibers of 100 percent virgin polyolefin conforming to ASTM D7508. Dose at 1.5 to 3 pounds per cubic yard (0.9 to 1.8 kilograms per cubic meter) of concrete.

725.18 Epoxy Resin Adhesives. Furnish epoxy resin adhesives conforming to AASHTO M 235 for structural concrete injection and crack repair.

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